Progress in U.S. Tsunami Forecast

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Tsunami Forecast

Real-time:

- Event-specific
- Real-time event assessment
- Real-time impact assessment before tsunami arrival

Long-term:

- Site-specific
- Probable Maximum Tsunami
- Multiple scenarios for PTHA
- Comprehensive Hazard Assessment

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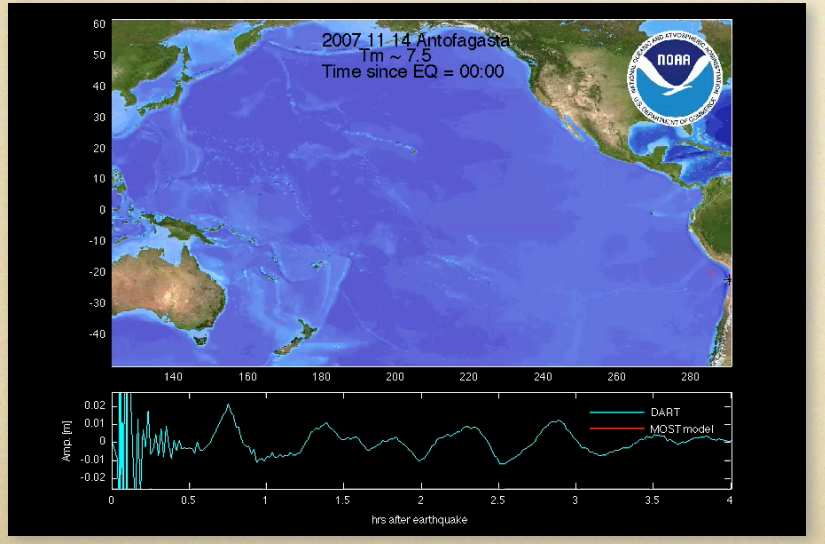

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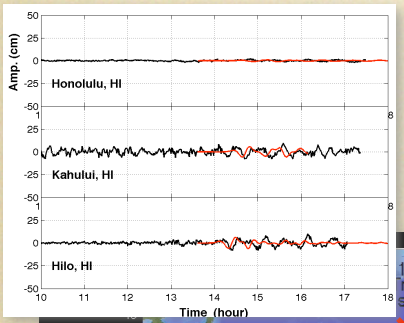

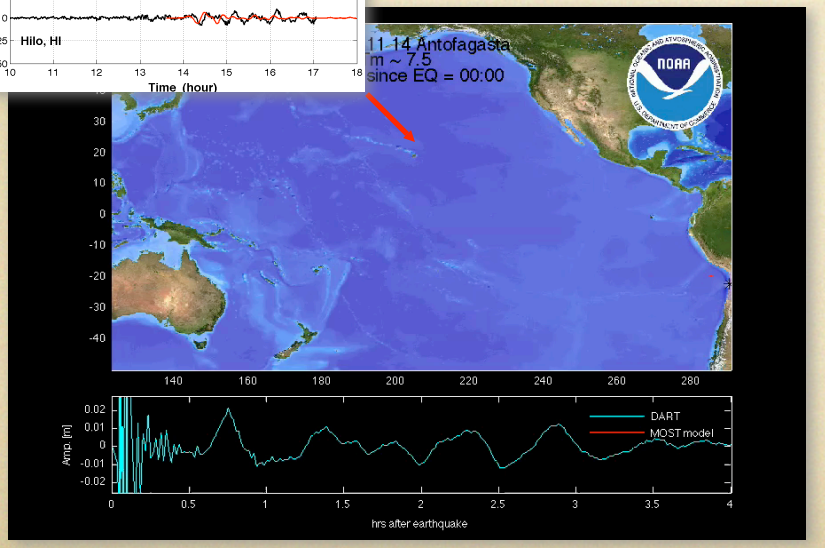

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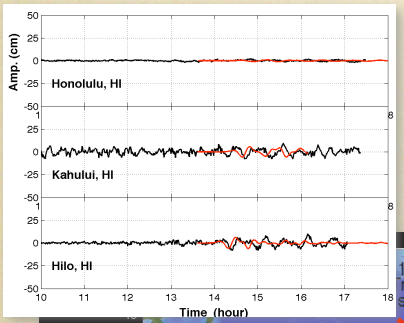

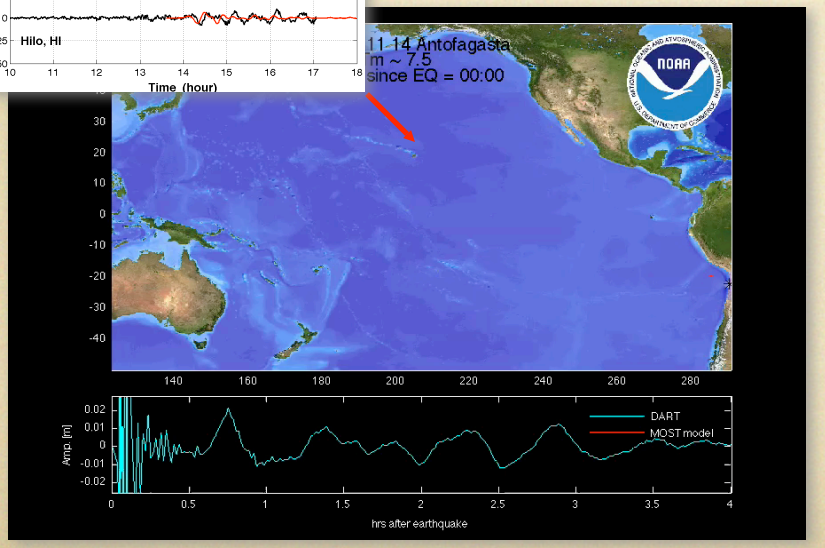

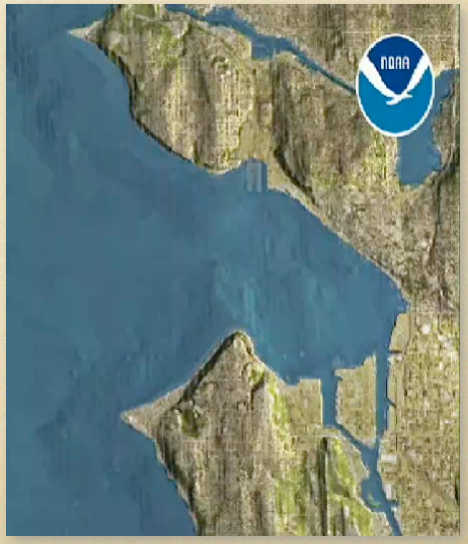

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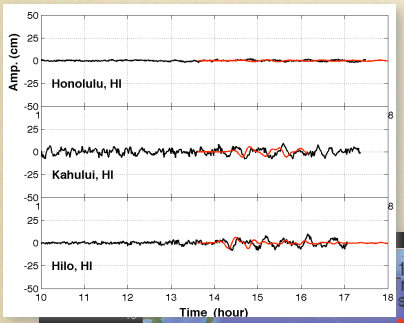

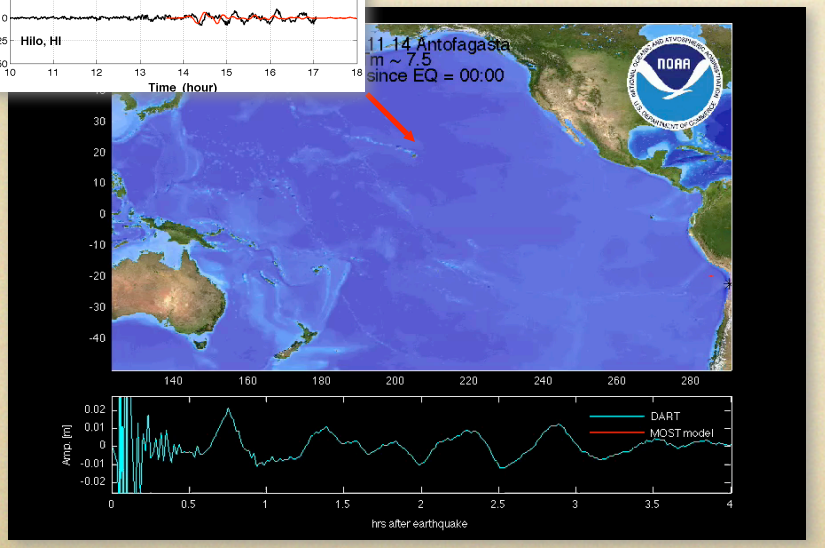

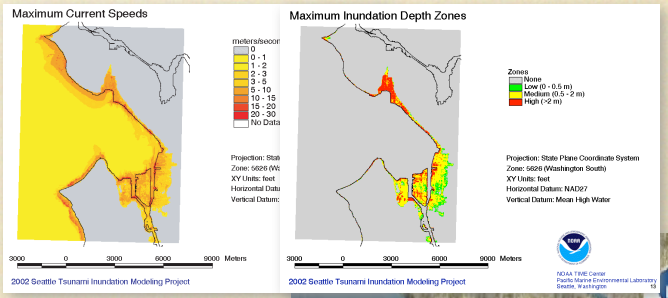

Challenges of Real-time Tsunami Forecast

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Brief history of tsunami modeling (1990-2000)

International Decade for Natural Disaster Reduction

- 1990 first NSF workshop on tsunami models
  Modeling problems identified: little data for testing (MOST model first introduced)
- 1992-95 Conical Island experiments
- 1995 2nd NSF workshop on tsunami models
  First benchmark tests (MOST model first tests)
- 1997 NSF workshop on tsunami sources:
  - no real-time source parameters, from seismic data
  - value of deep-ocean tsunami measurements.

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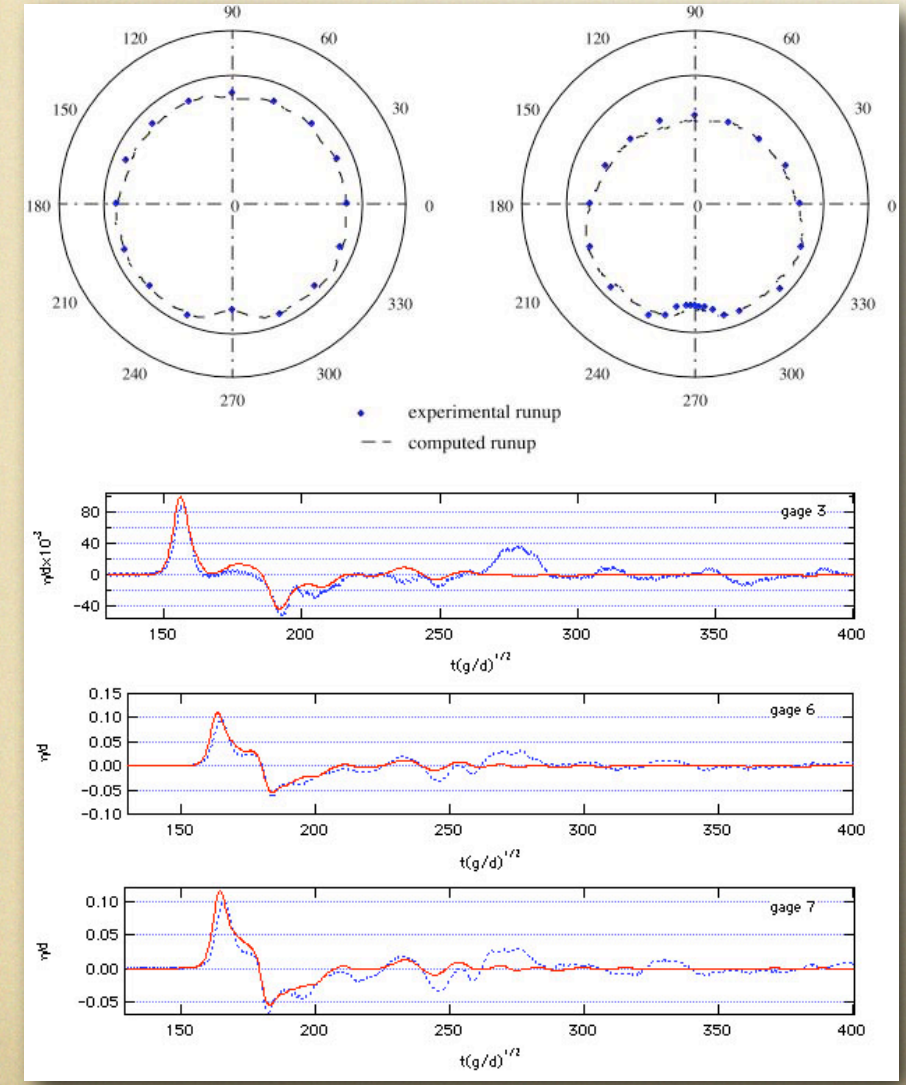
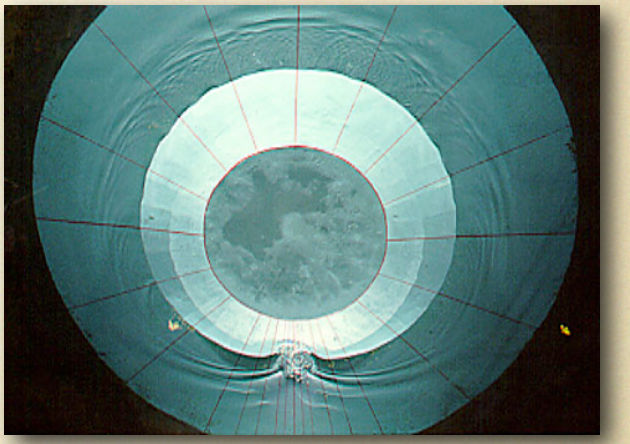
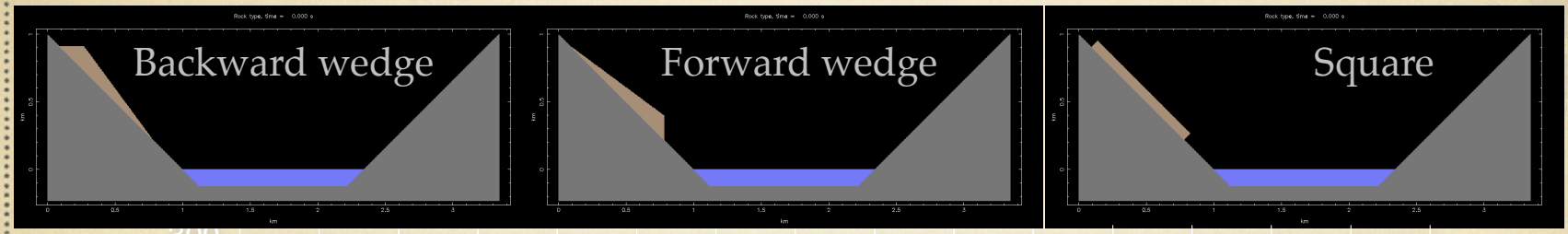




Friday Harbor Workshop Benchmarks (*Yeh, H. P. Liu and C. Synolakis (ed), 1996*)

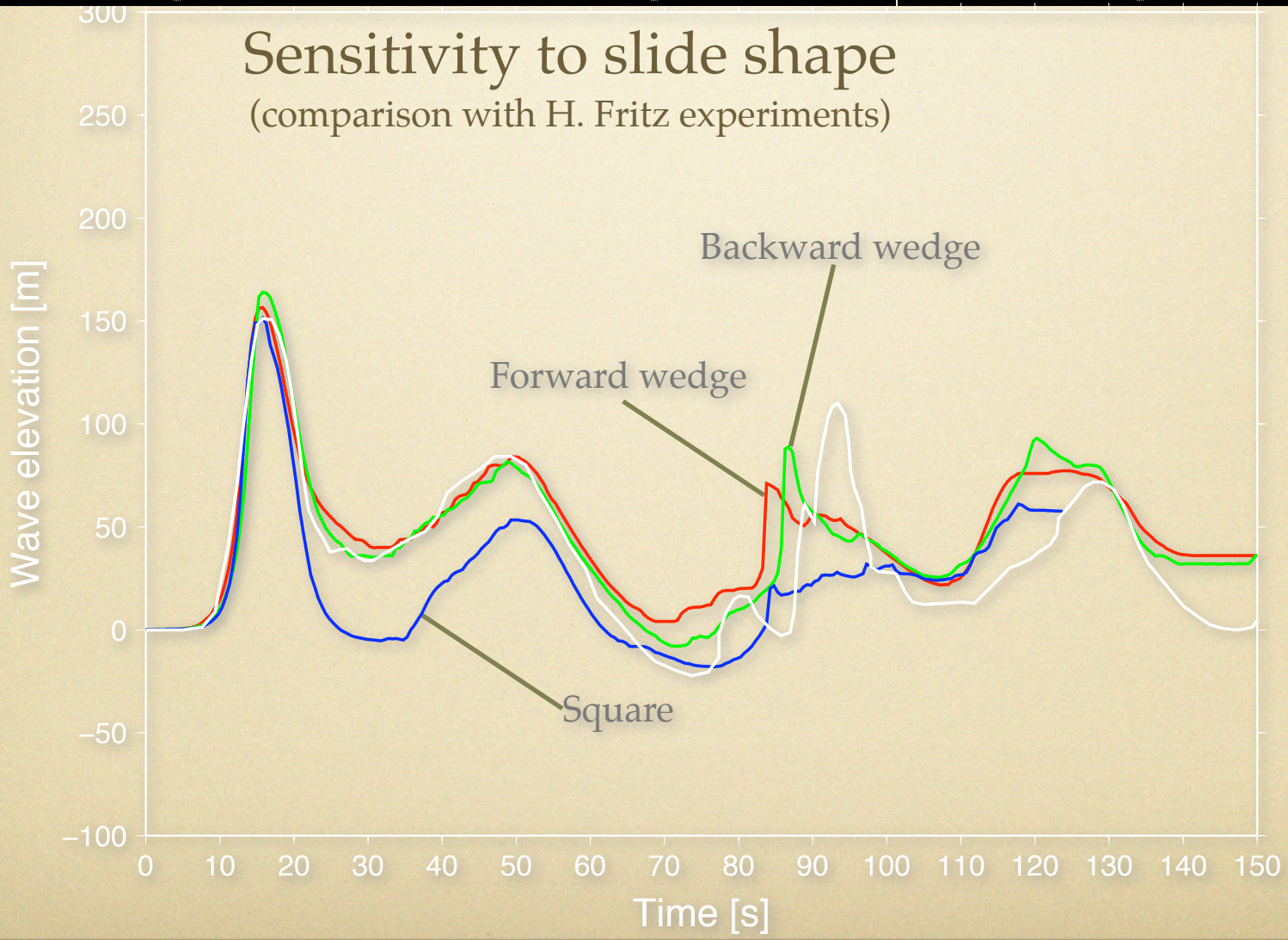
Runup of a solitary wave on a conical island (*Briggs, Synolakis, Green, Harkins, 1995*)

Landslide Model Validation



Sensitivity to slide shape

(comparison with H. Fritz experiments)



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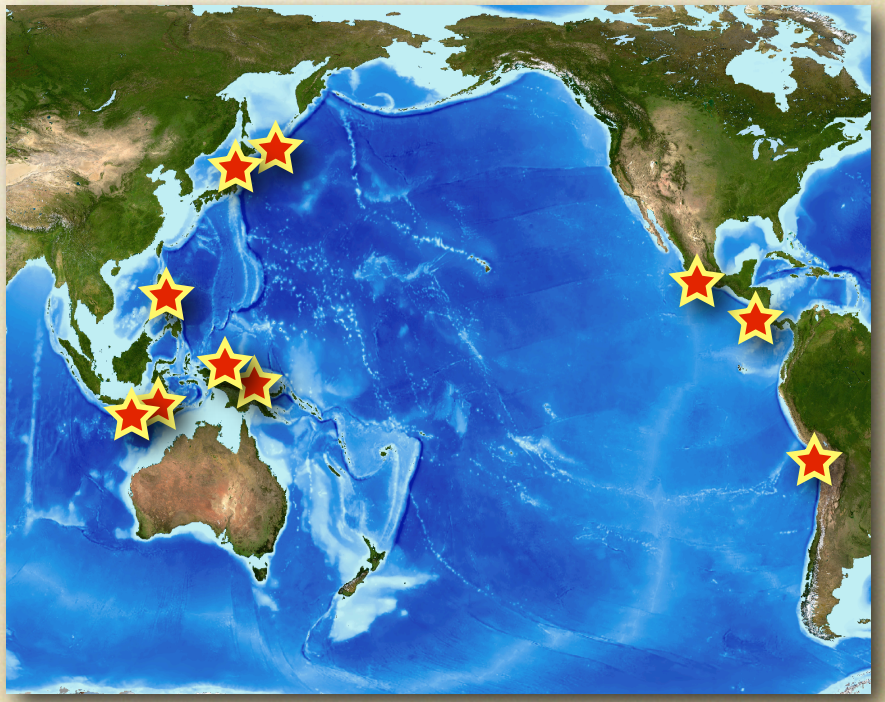
Surveys of destructive tsunamis for models verification (1990 - 2000)



Over 4,000 people died

- 1992 Nicaragua (170)
- 1992 Flores Island, Indonesia (1000)
- 1993 Okushiri Island, Japan (239)
- 1994 E. Java, Indonesia (238)
- 1994 Kuril Islands, Russia (11)
- 1994 Mindoro Is, Philippines (49)
- 1996 Irian Jaya, Indonesia (161)
- 1996 Chimbote, Peru (12)
- 1998 Papua New Guinea (2182)

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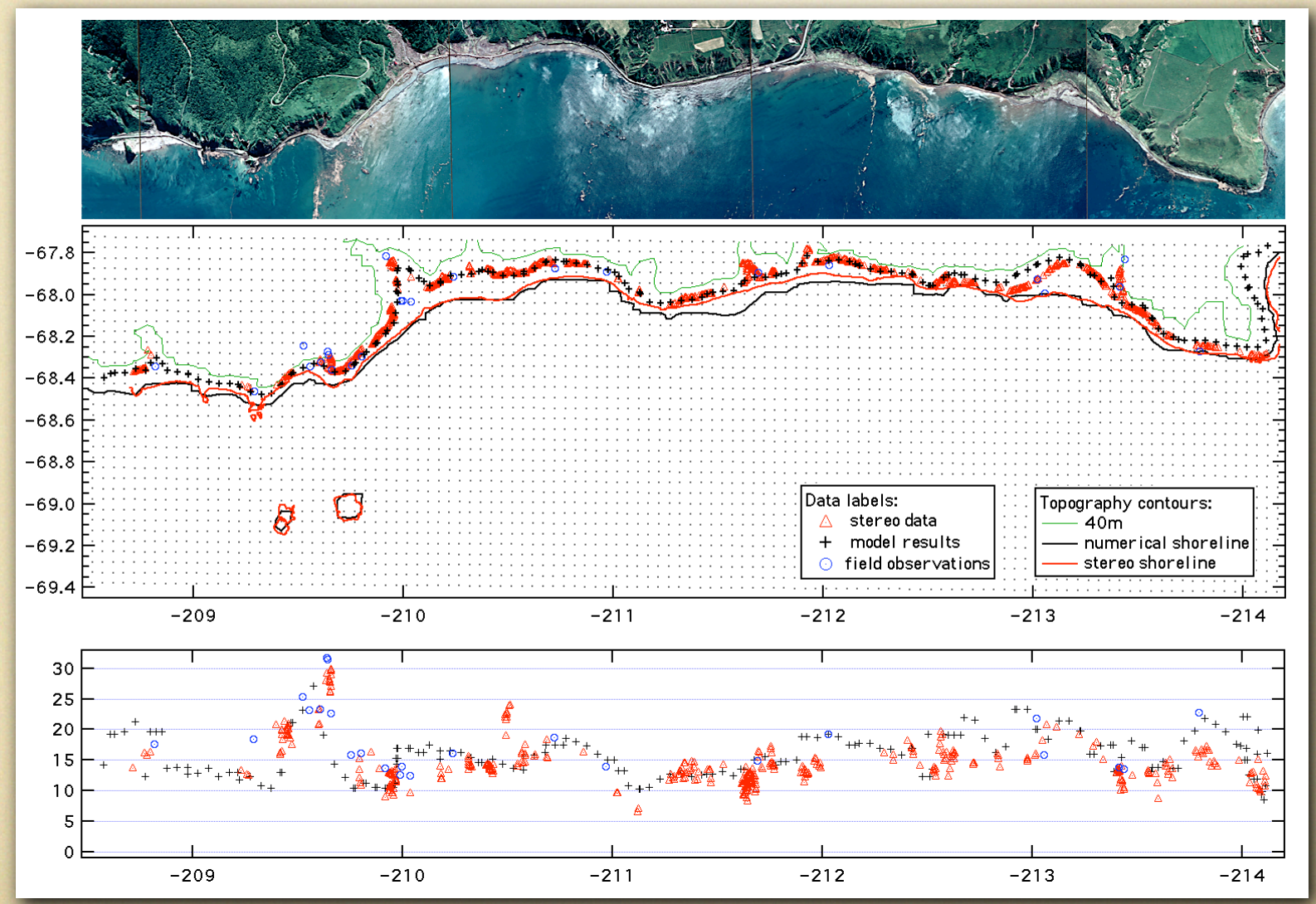

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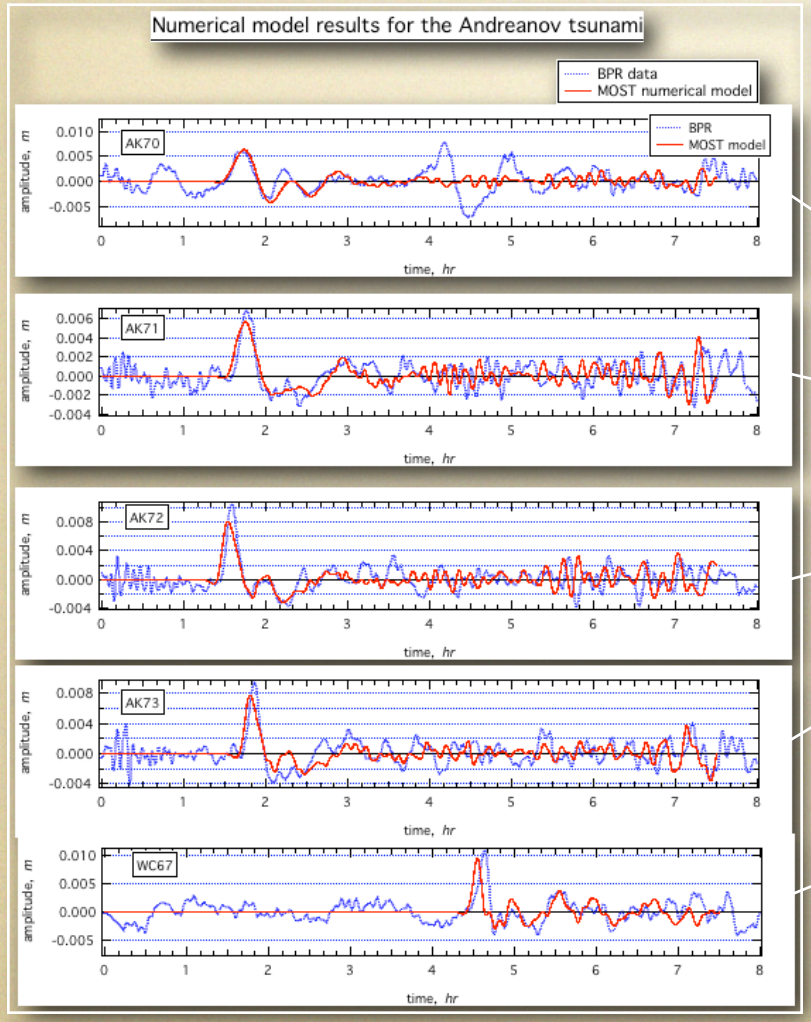
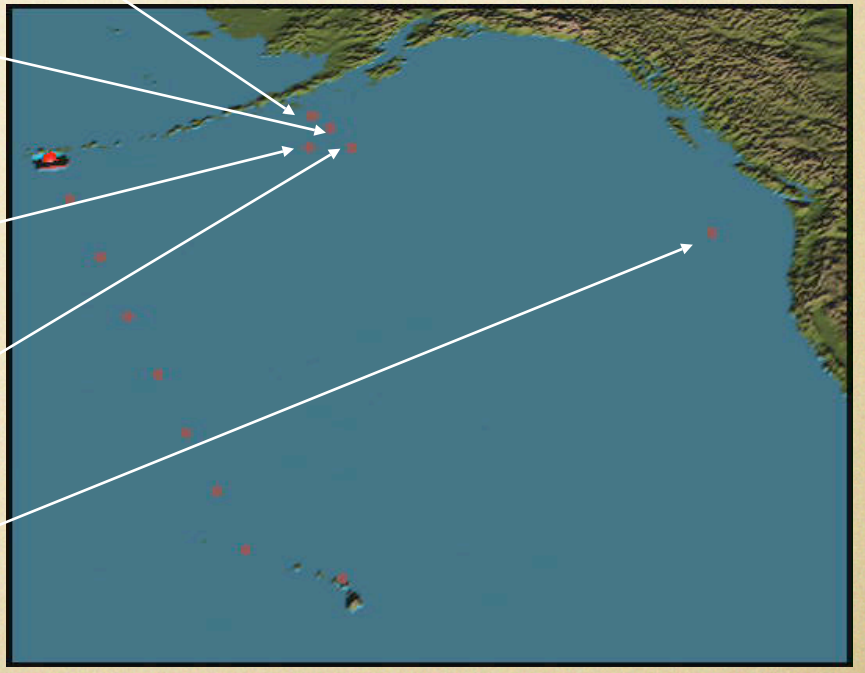


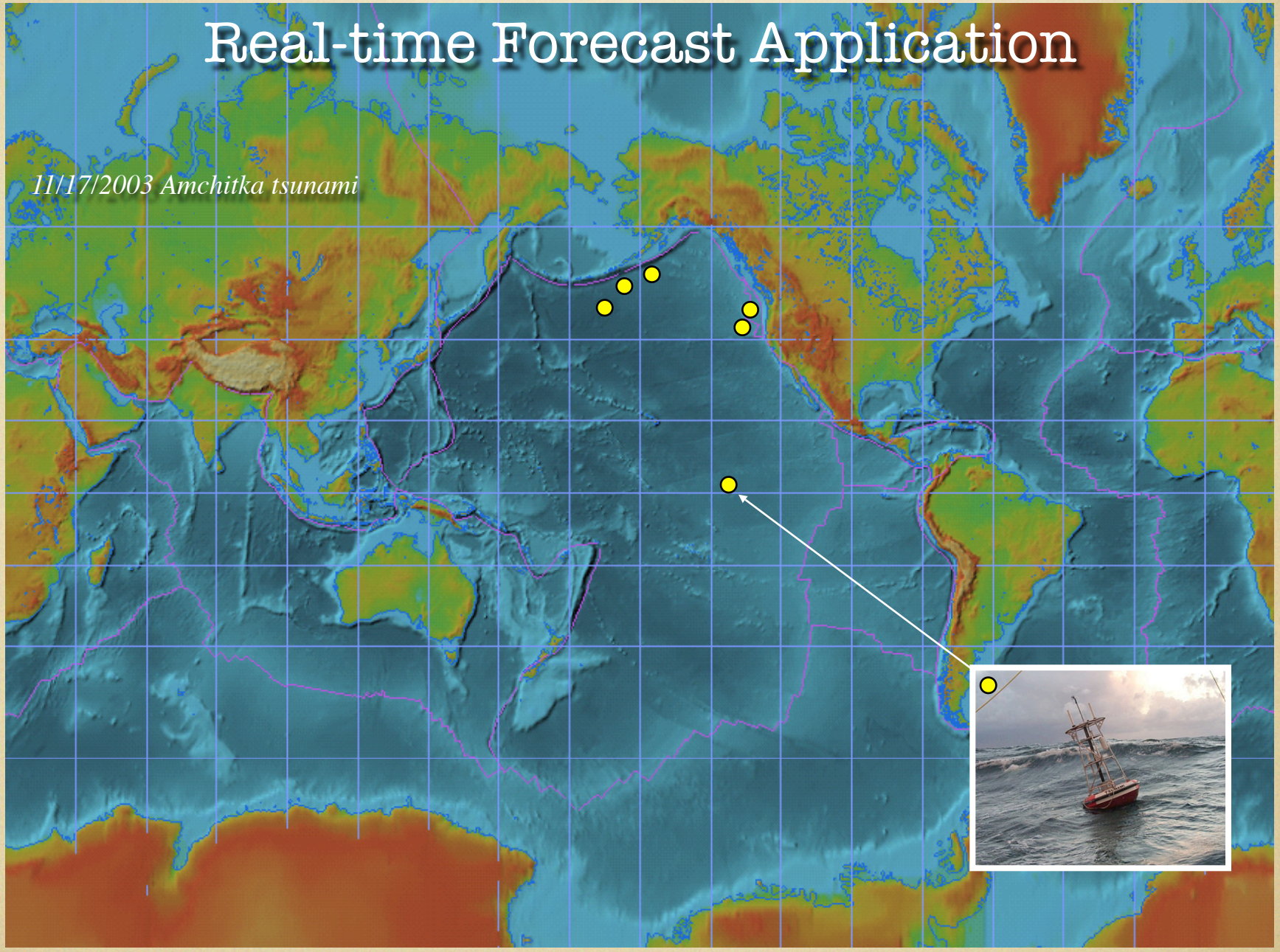
Deep-ocean measurements become available

June 10, 1996 Andreanov tsunami (Titov & Gonzalez, 1997)



Real-time Forecast Application

11/17/2003 Amchitka tsunami



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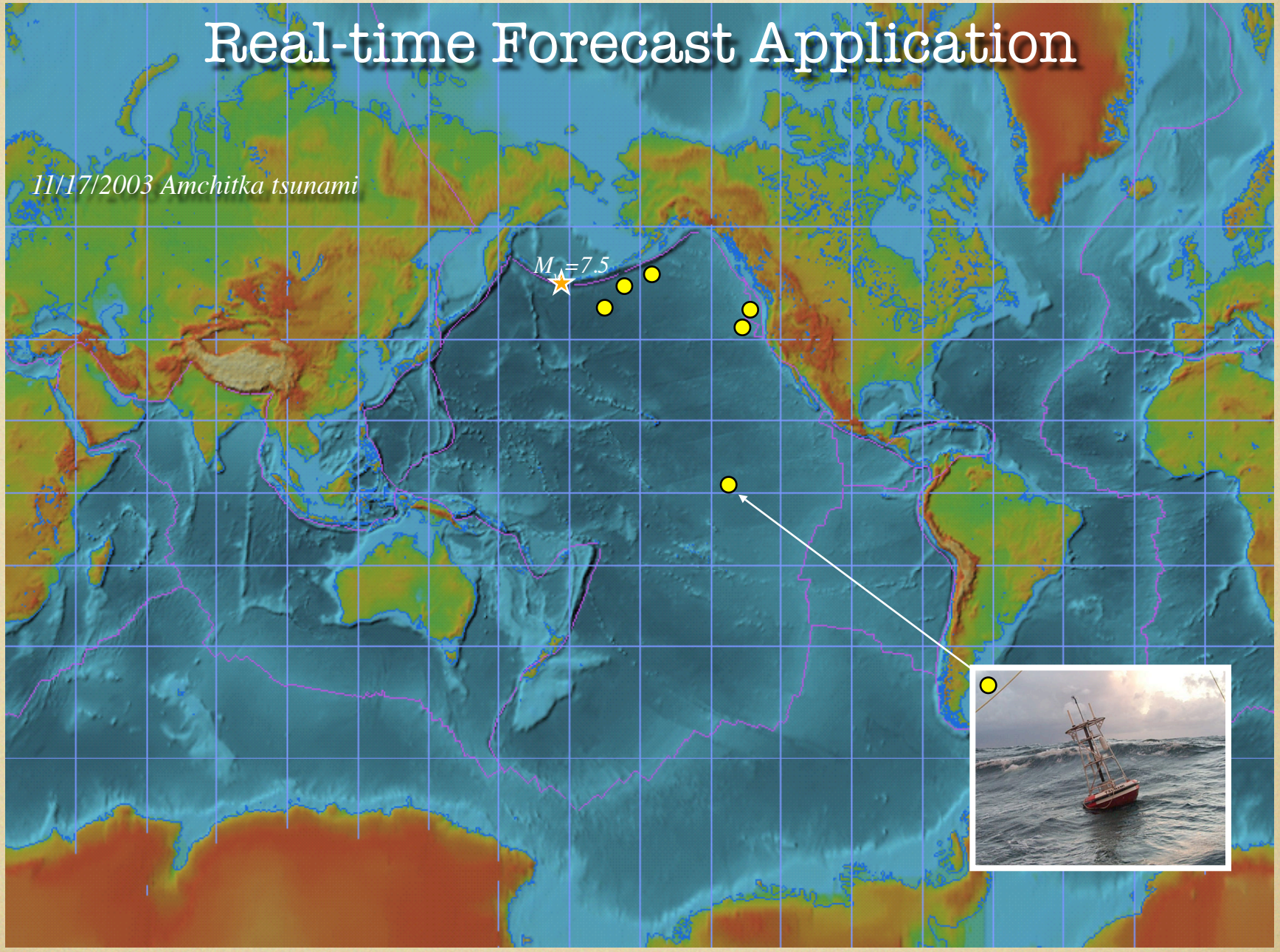

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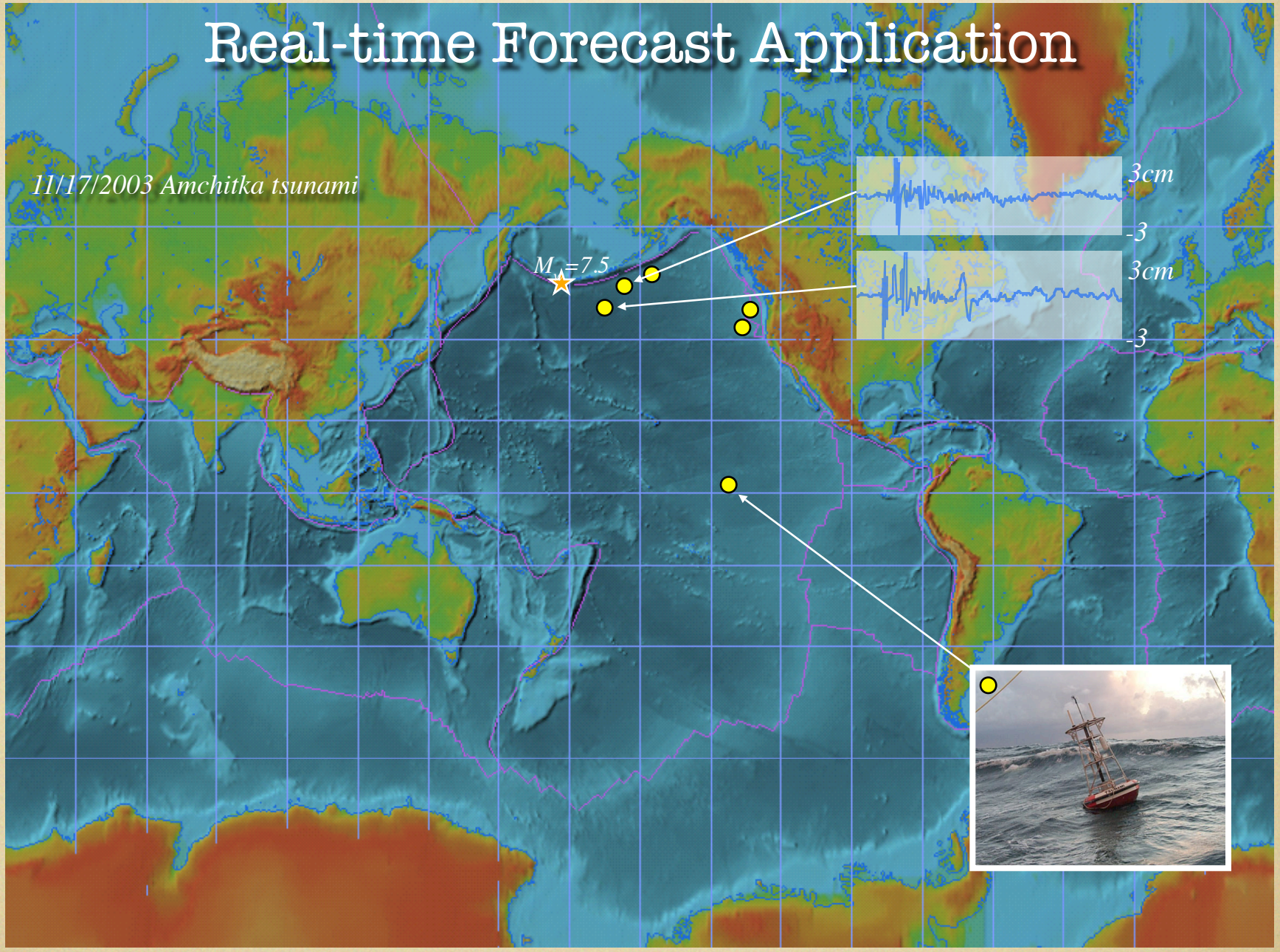

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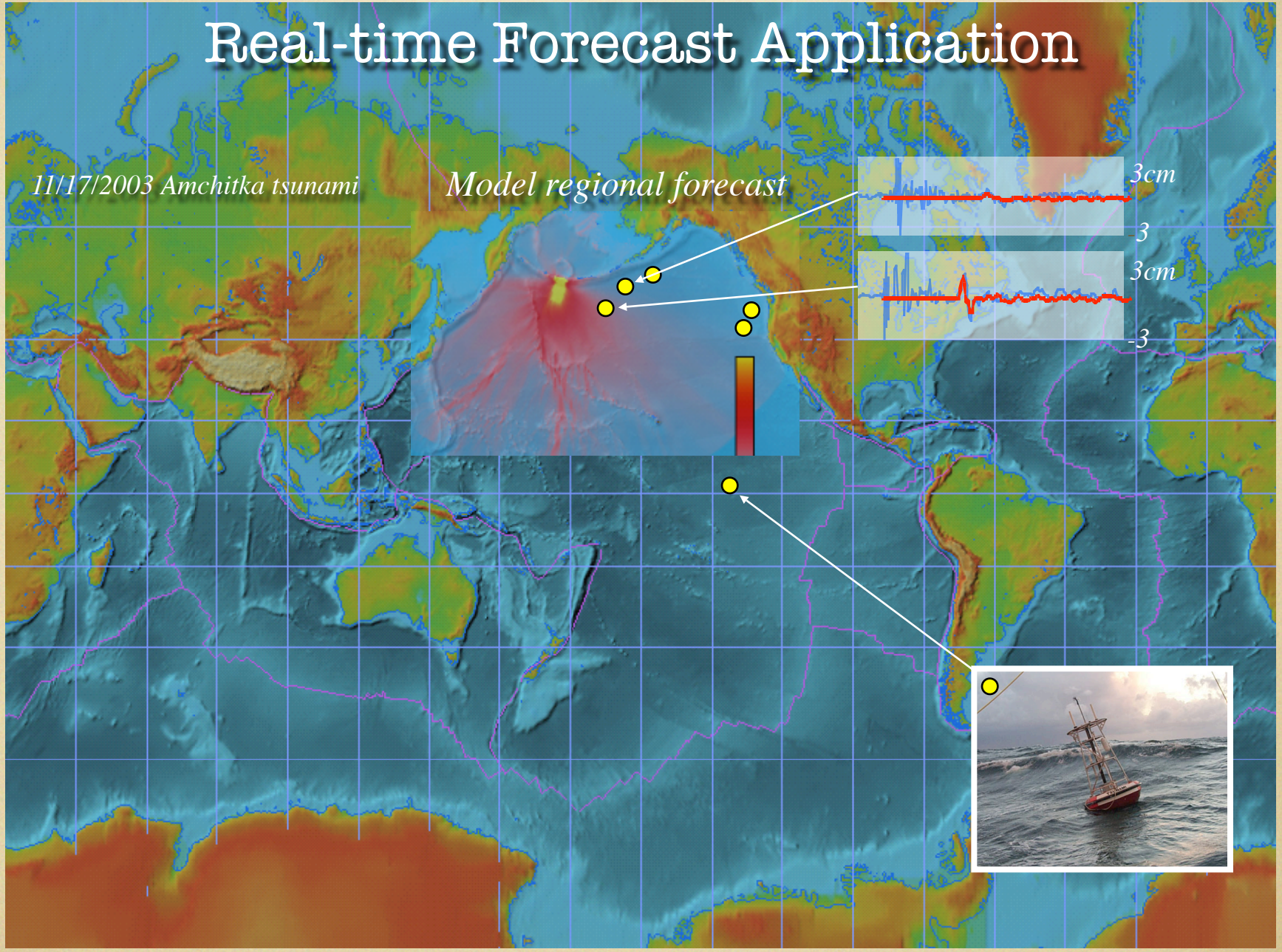

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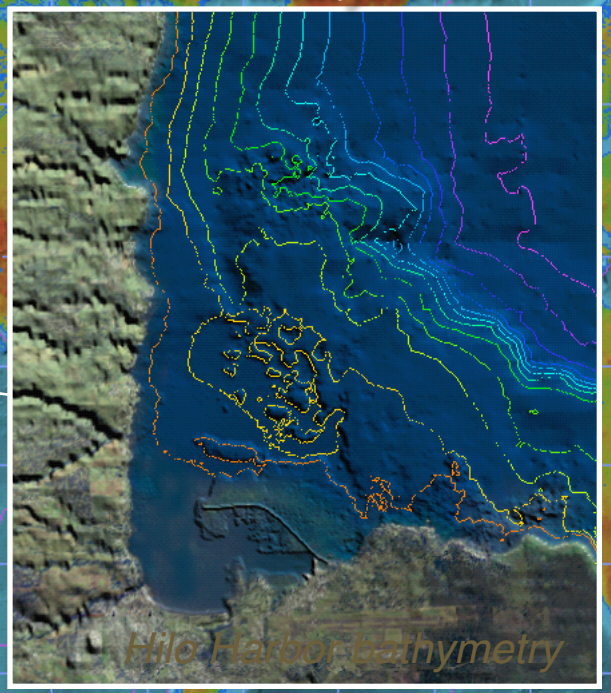

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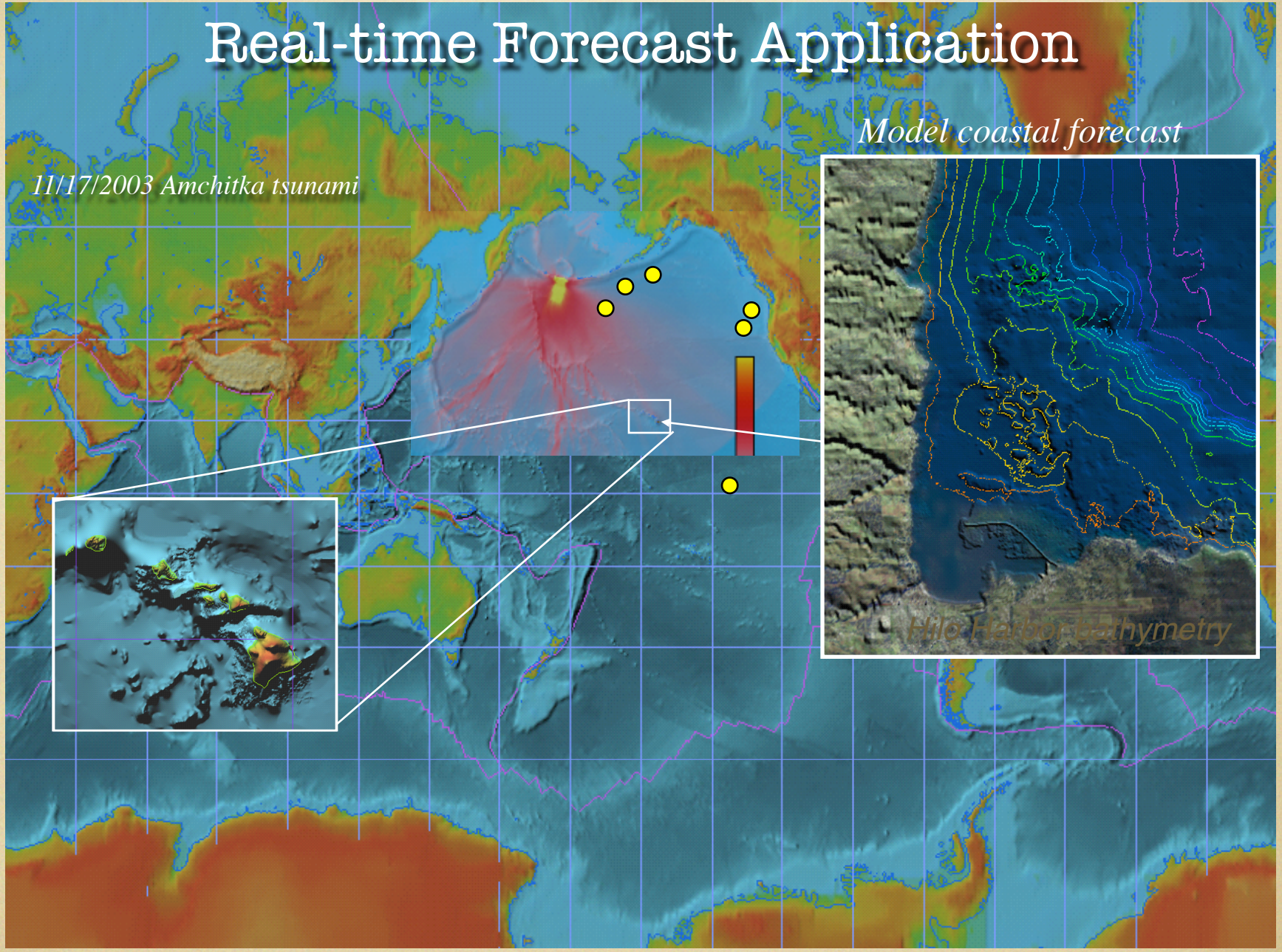

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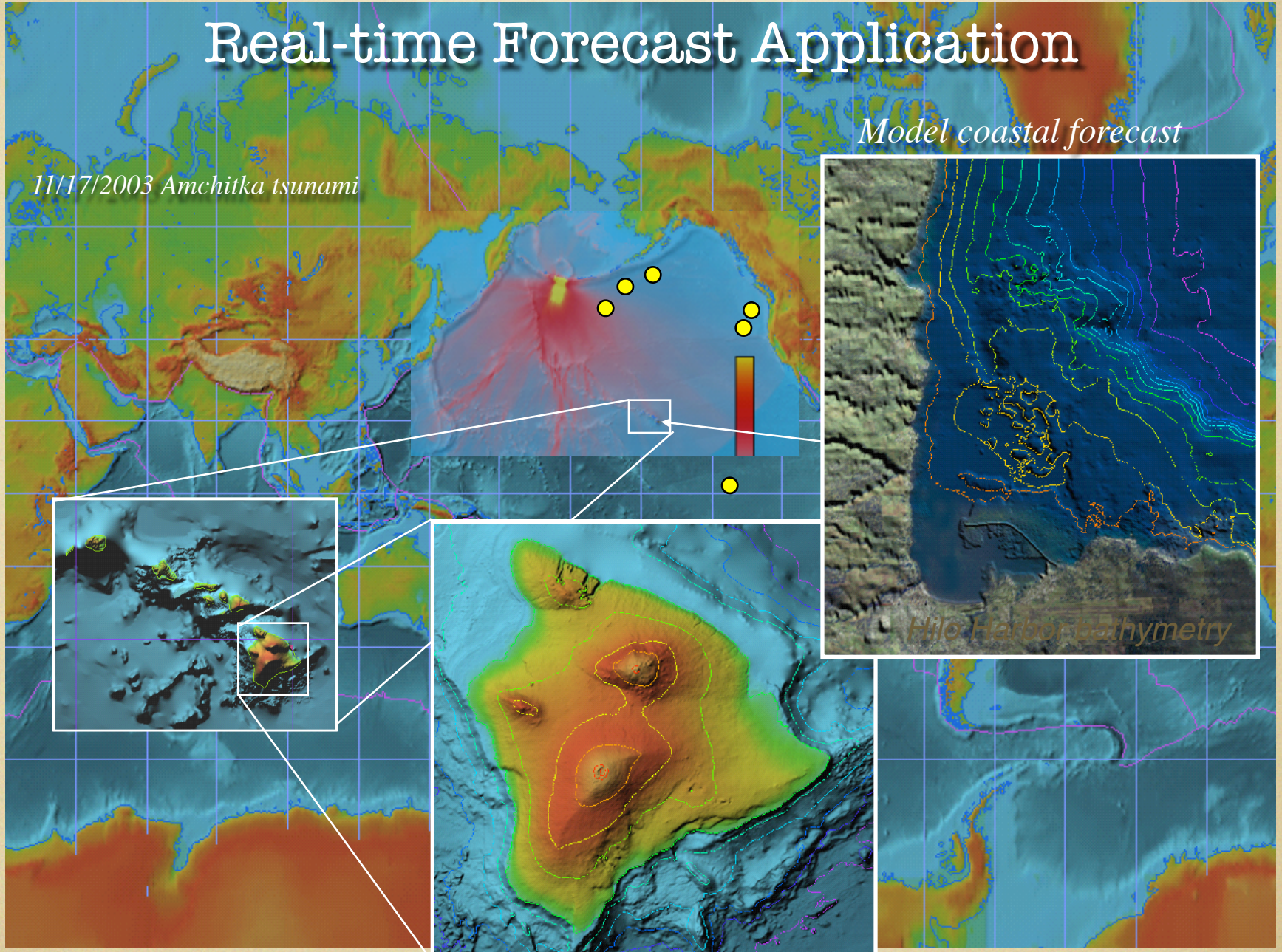

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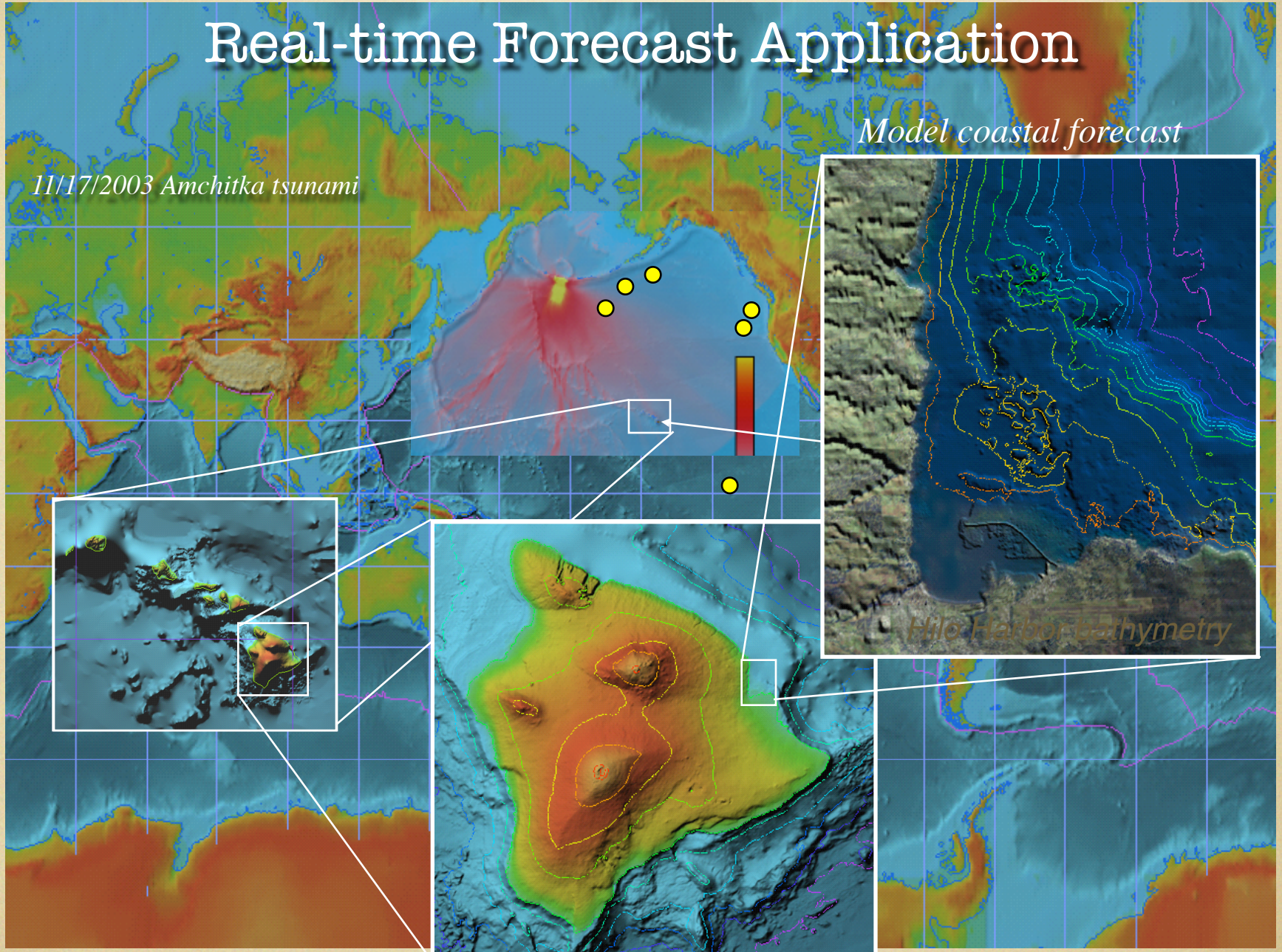

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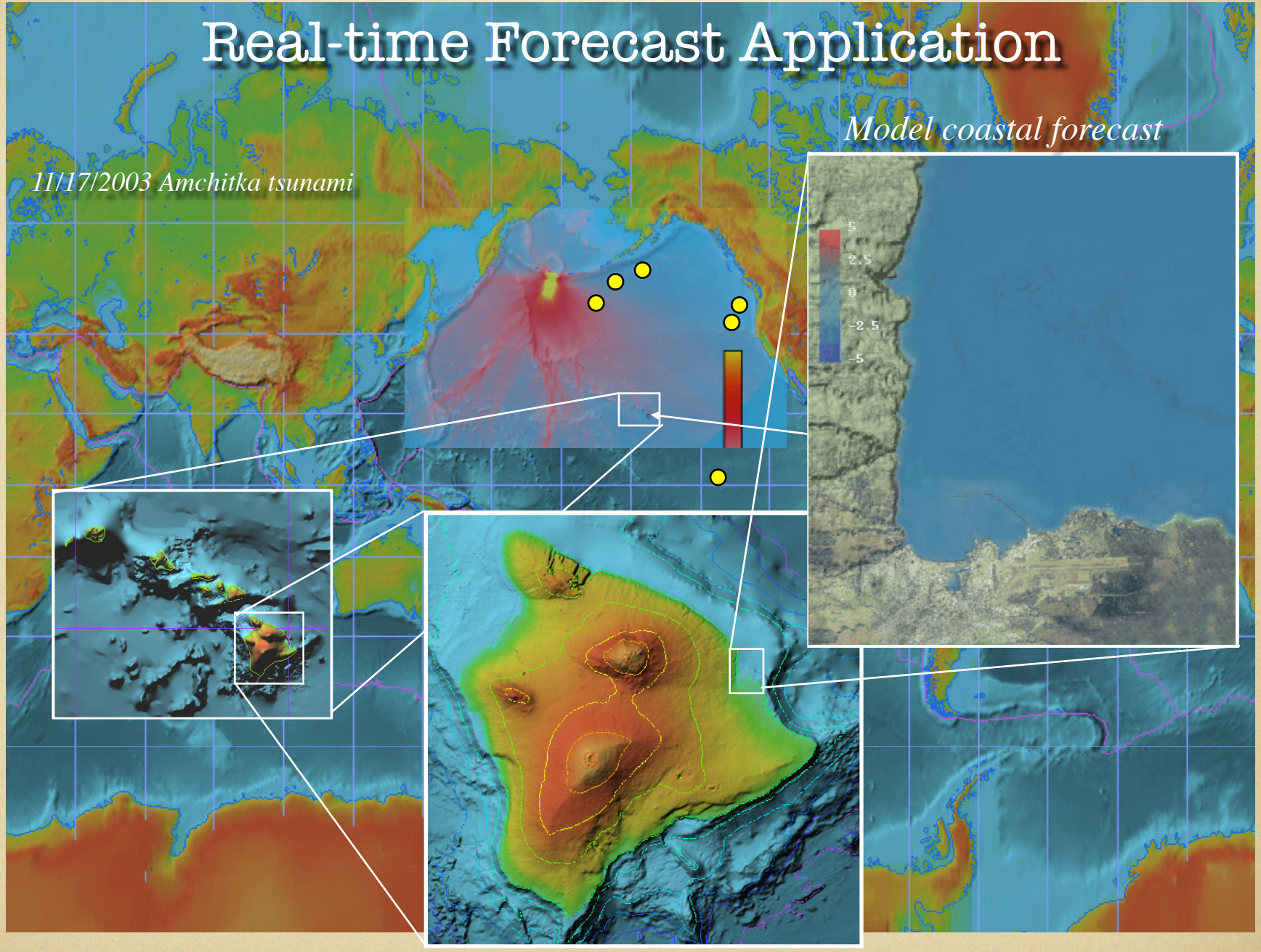

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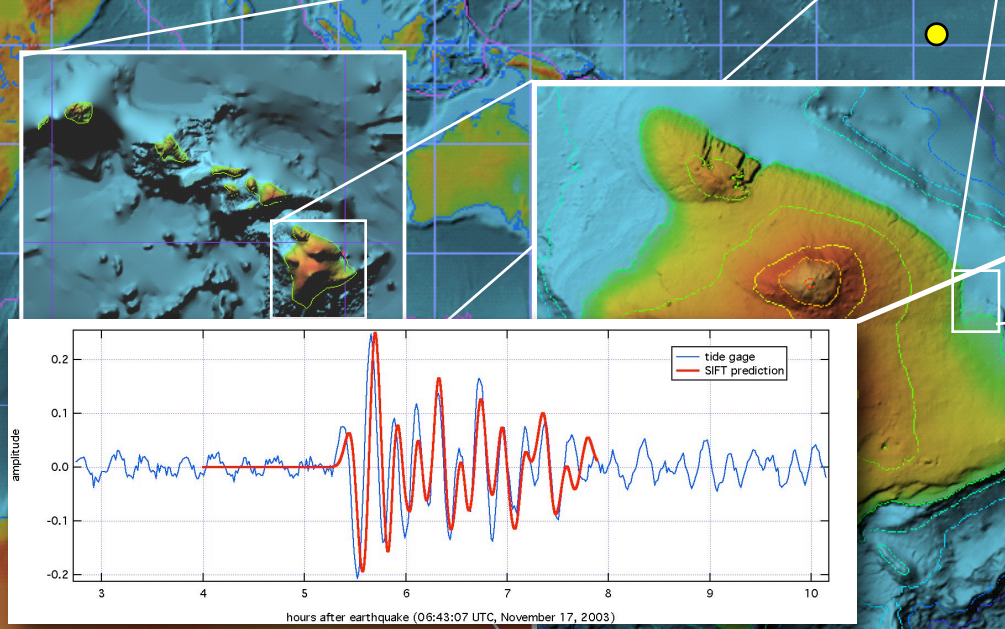
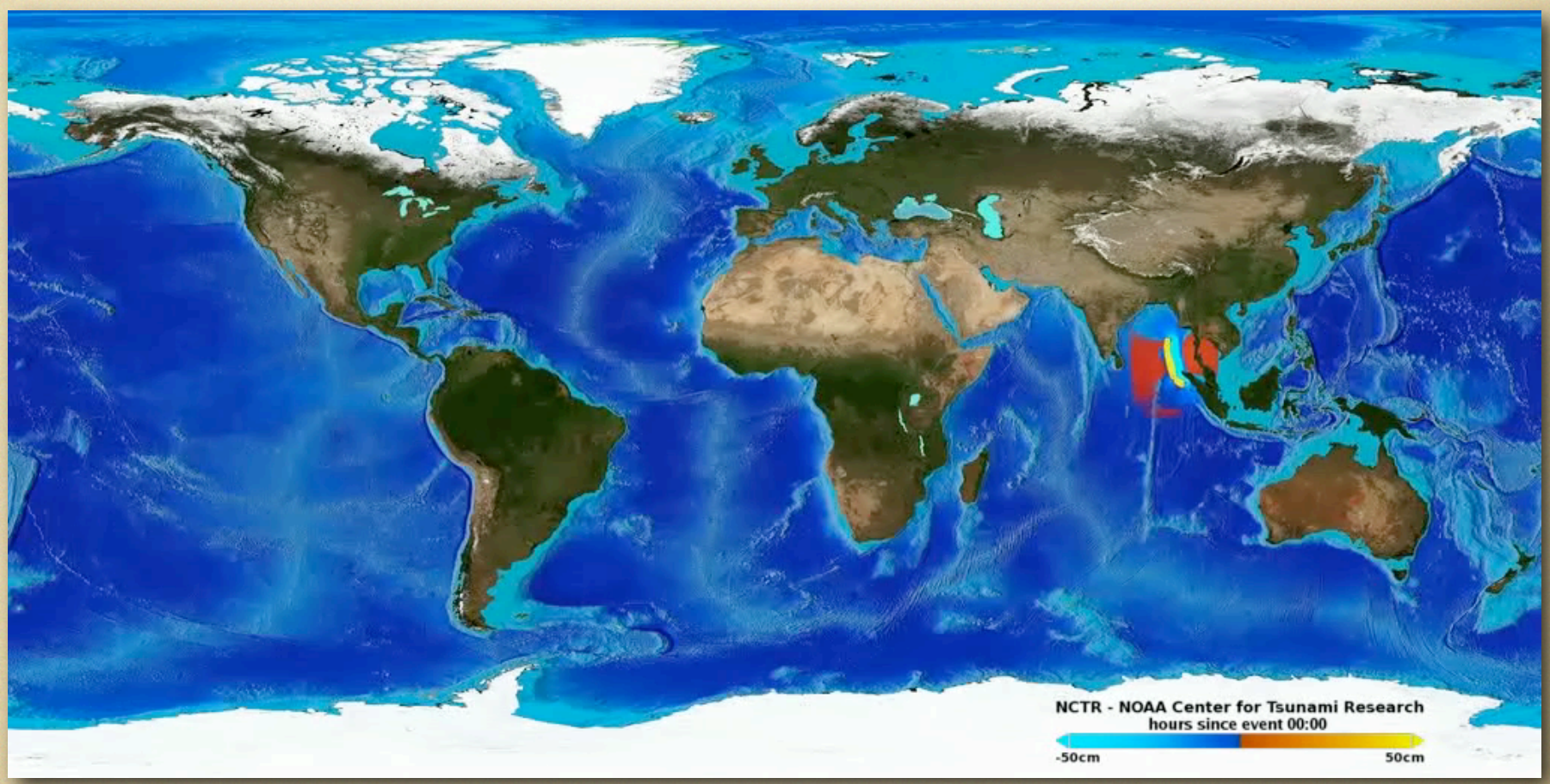


December 26, 2004

Tsunami Forecast Ultimate Test



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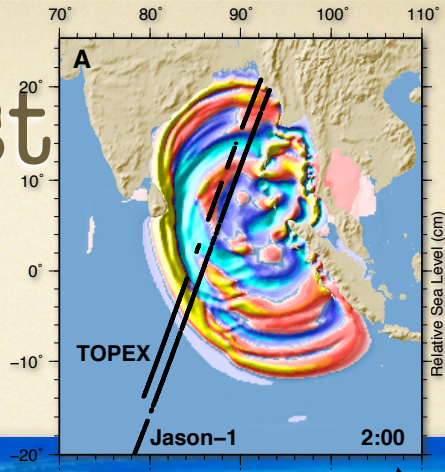

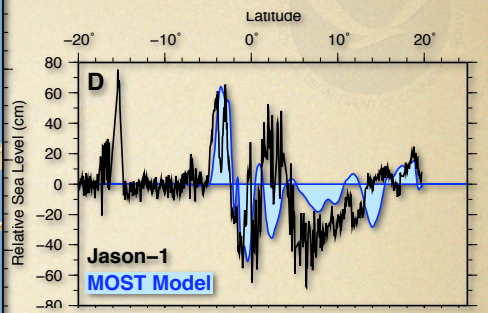

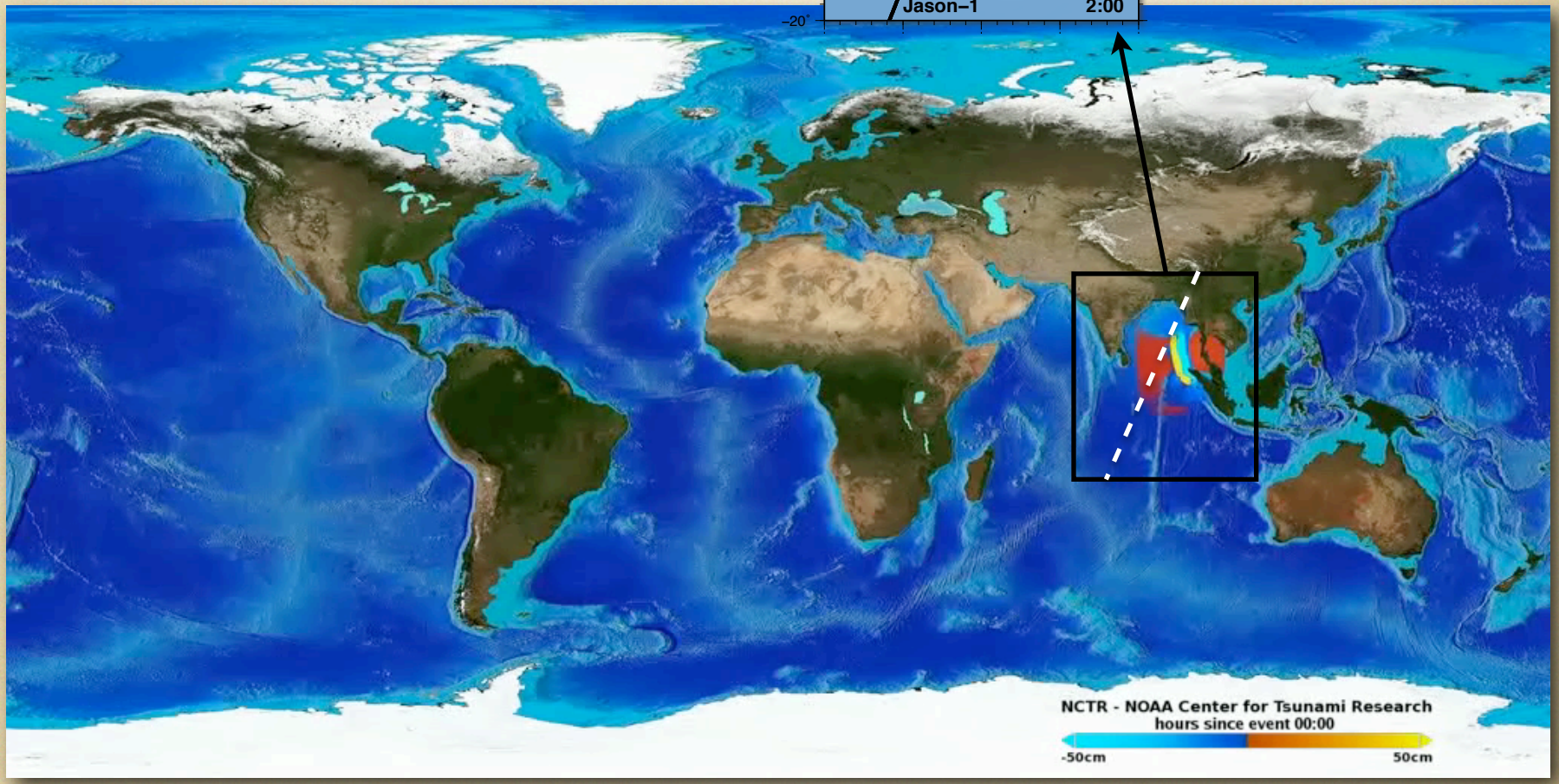

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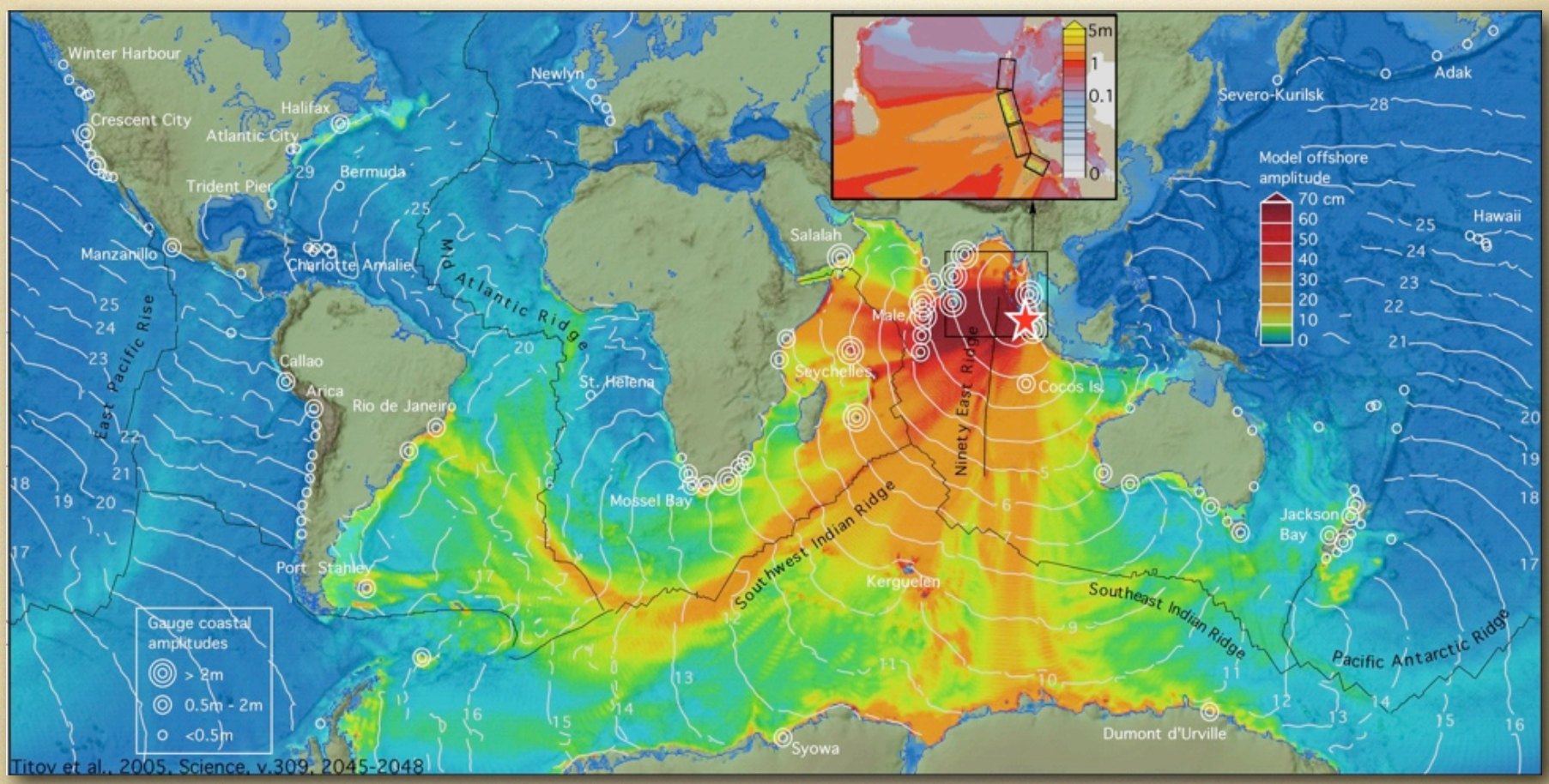

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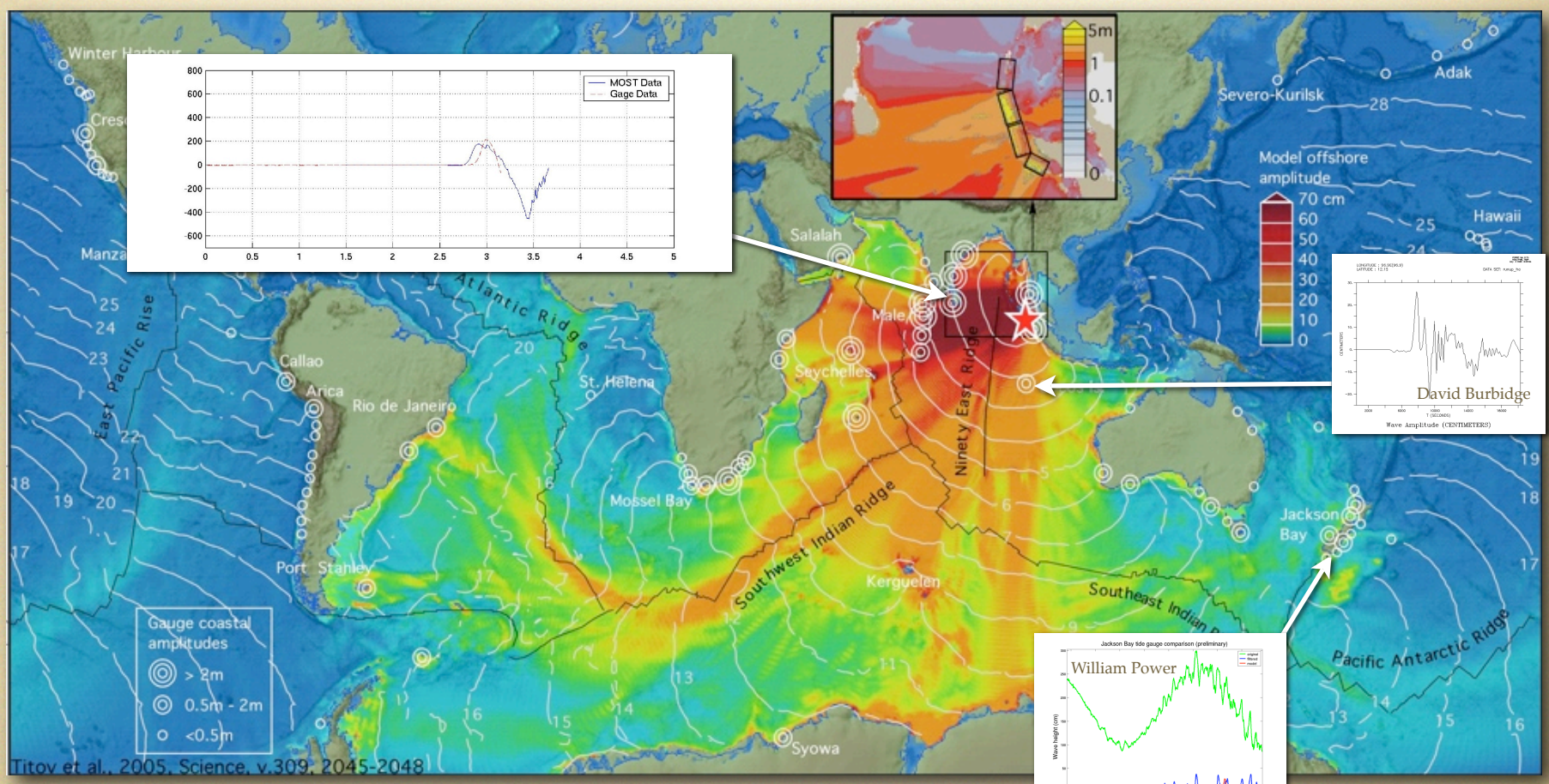

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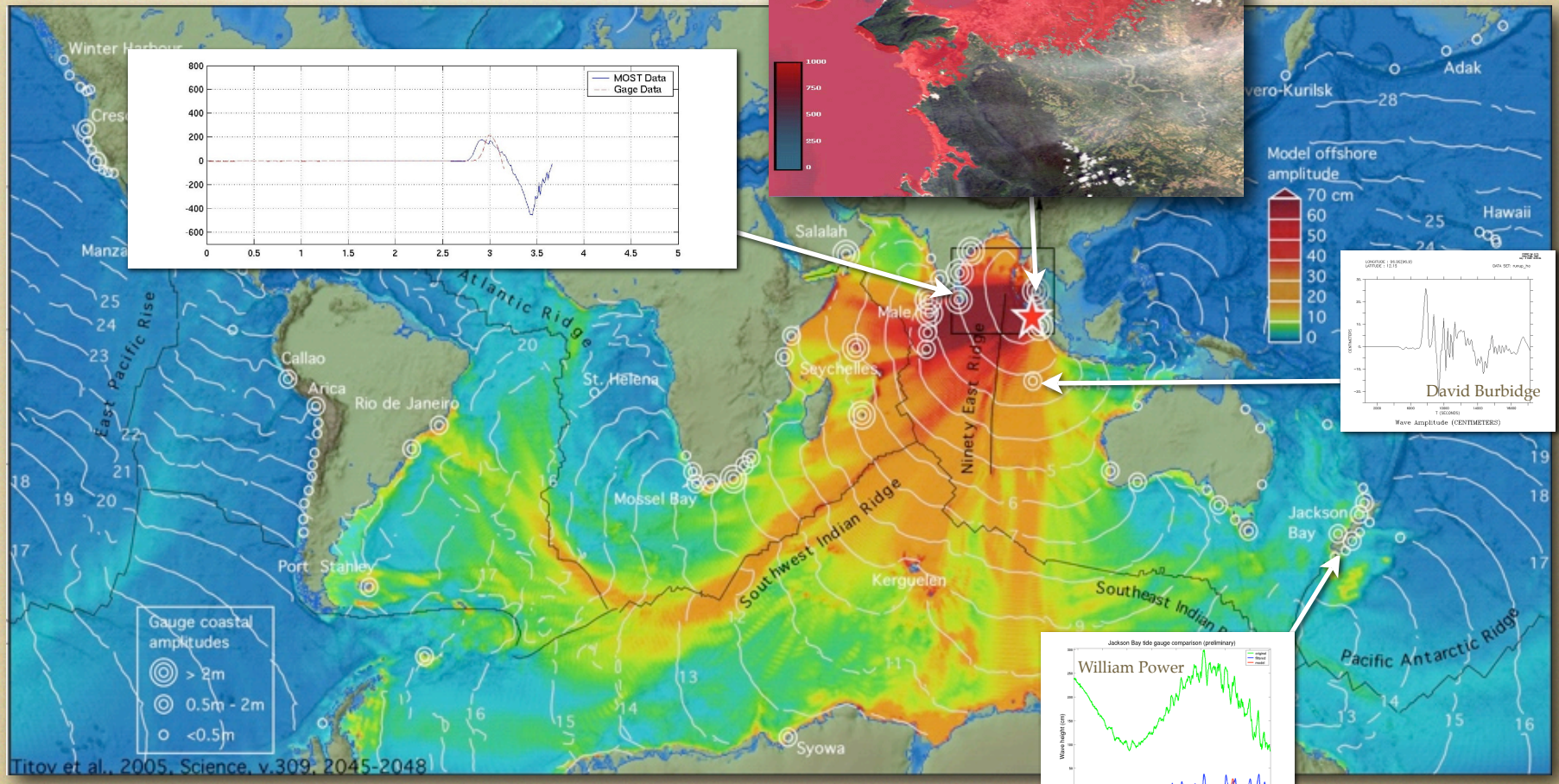
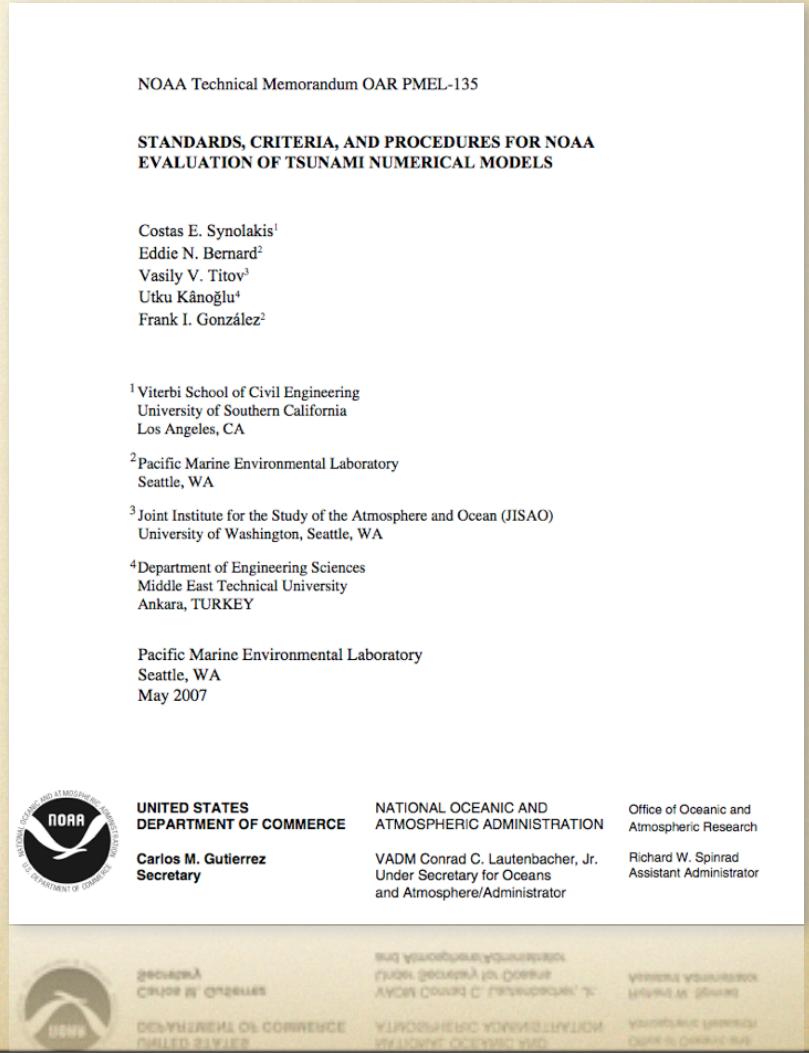


Model Standards for Operational Forecast

NOAA Forecast Model Standards

- **Peer-reviewed publication**. An must be published in peer-reviewed scientific journals with impact factors greater than one
- **Benchmarking**. The model must be tested against other peer models in a benchmark workshop, and the results documented in a report
- **Operational Assessment**. Important factors to be assessed include the model speed, accuracy, special operating environment needs, ease-of-use, and documentation



NOAA Technical Memorandum OAR PMEL-135

STANDARDS, CRITERIA, AND PROCEDURES FOR NOAA EVALUATION OF TSUNAMI NUMERICAL MODELS

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Frank I. González[2]

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May 2007

UNITED STATES DEPARTMENT OF COMMERCE
Carlos M. Gutierrez
Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
VADM Conrad C. Lautenbacher, Jr.
Under Secretary for Oceans and Atmosphere/Administrator

Office of Oceanic and Atmospheric Research
Richard W. Spinrad
Assistant Administrator

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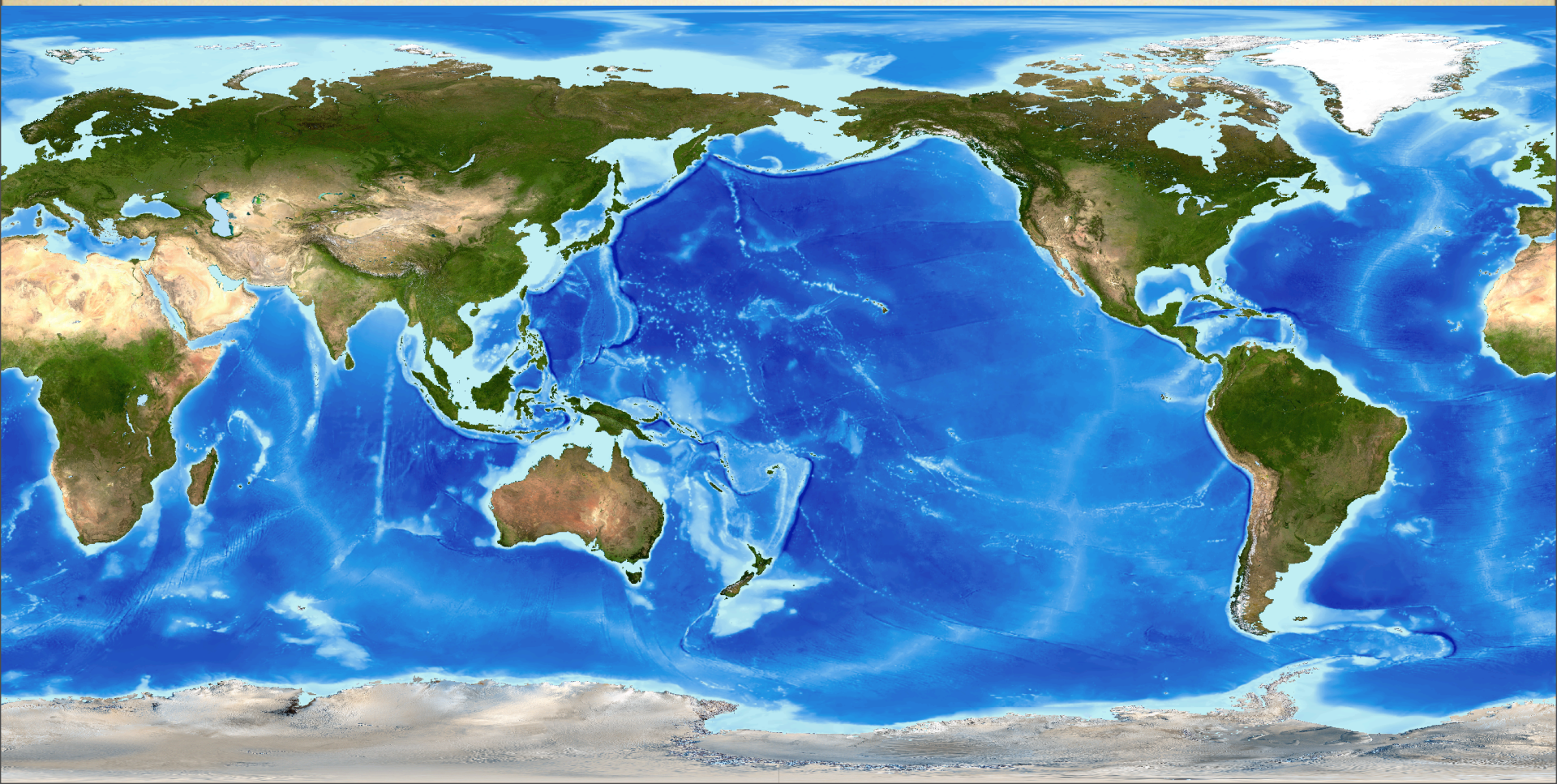

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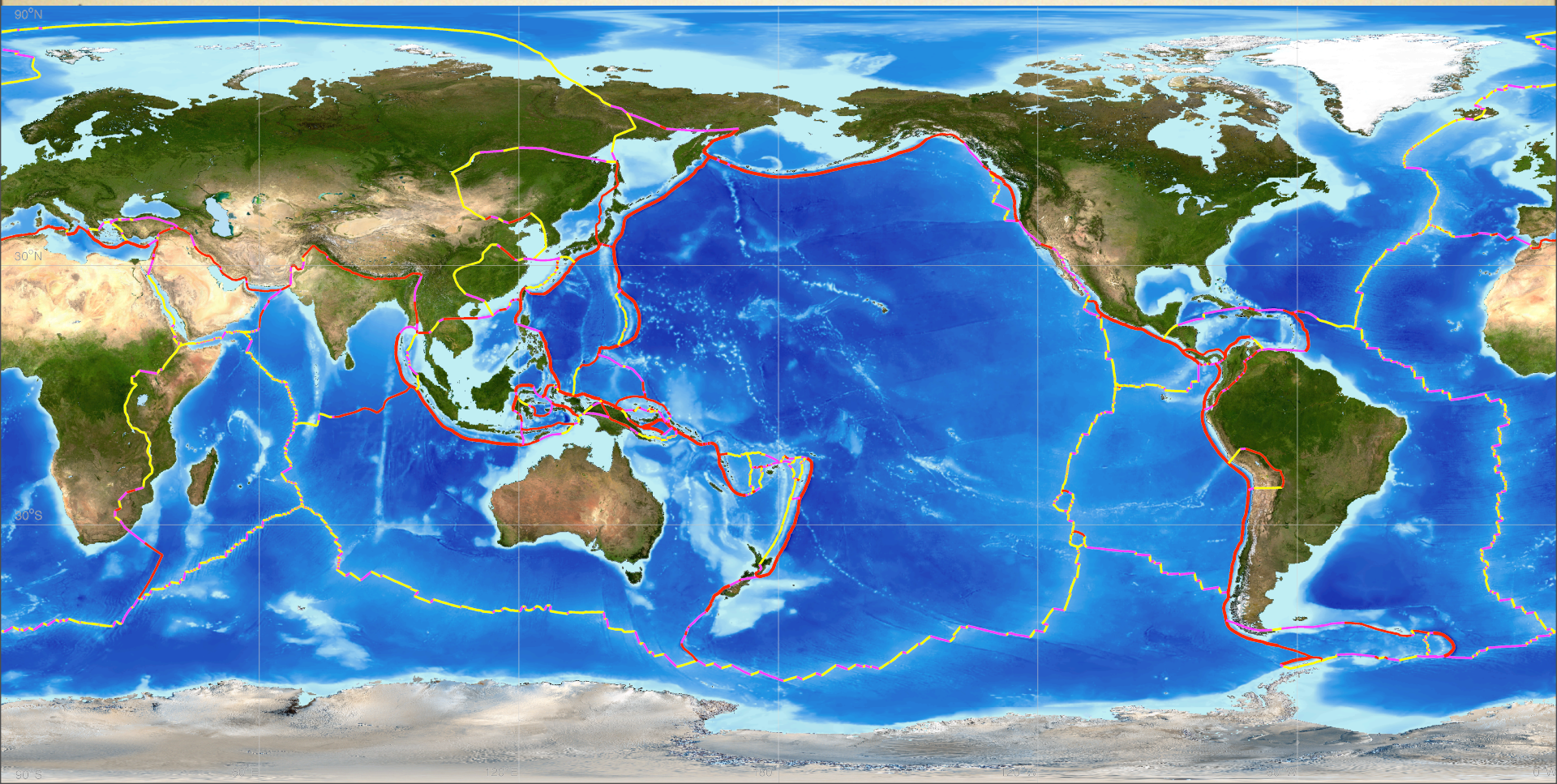

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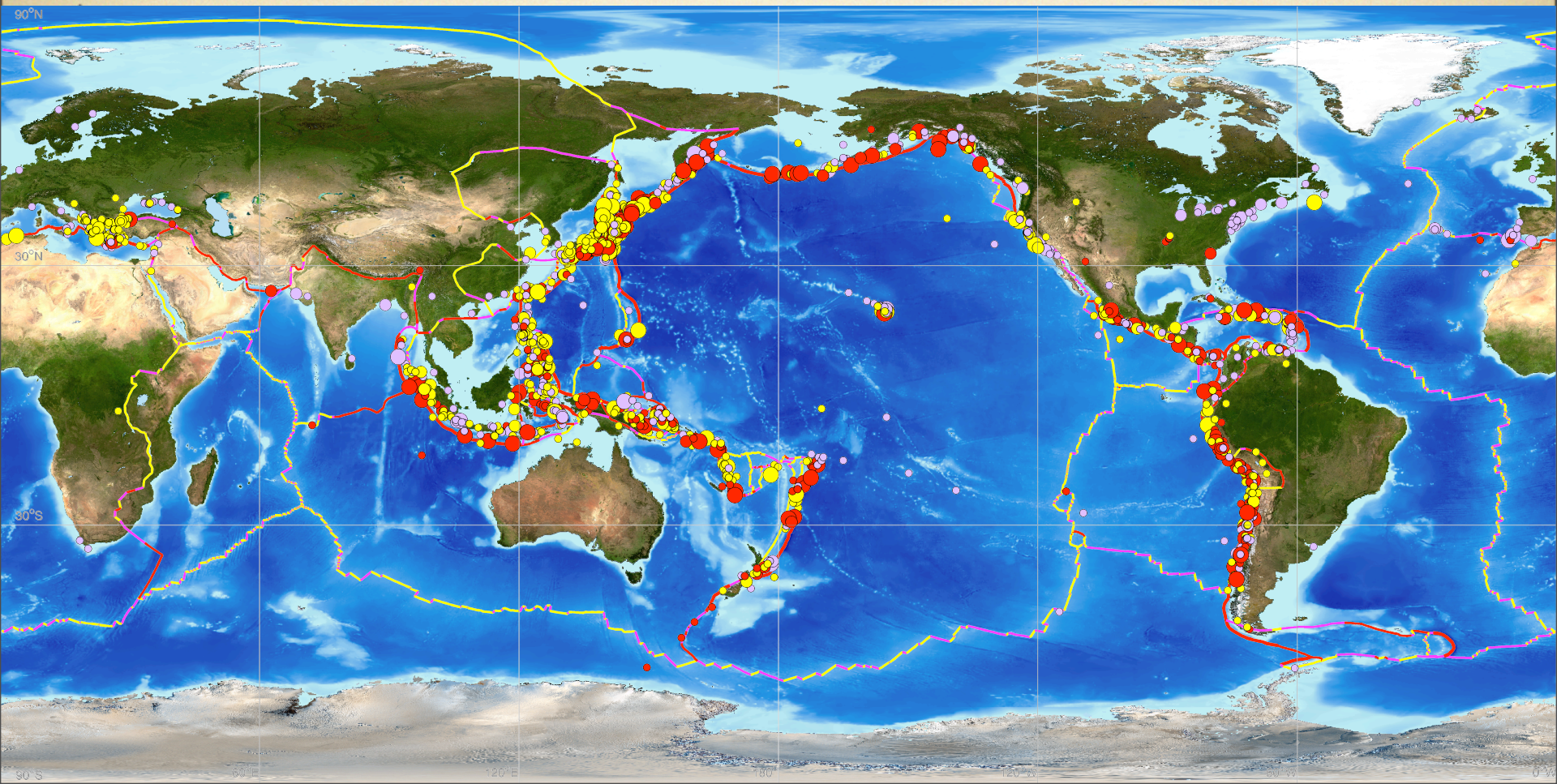

NOAA Tsunami Forecast

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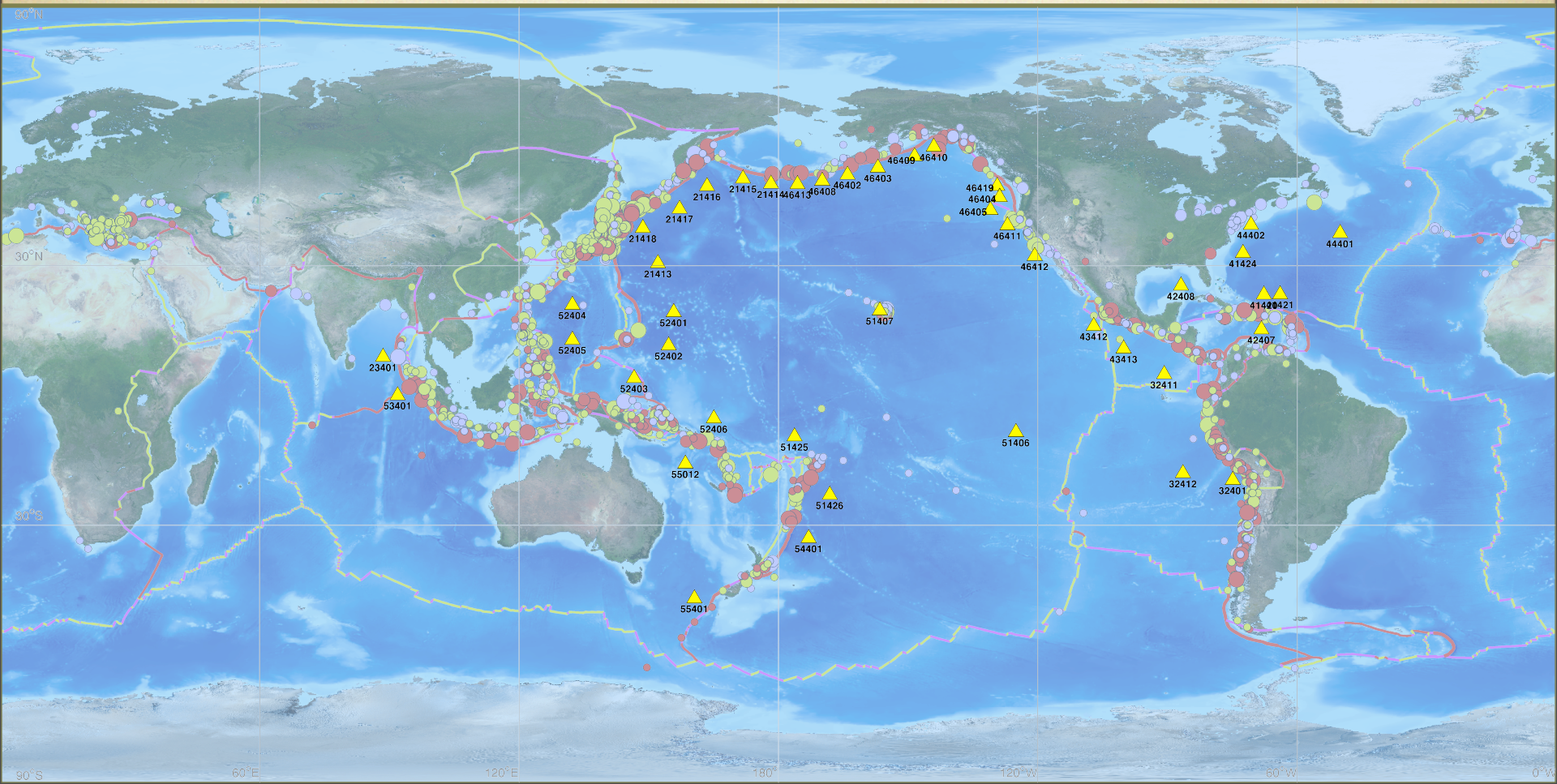

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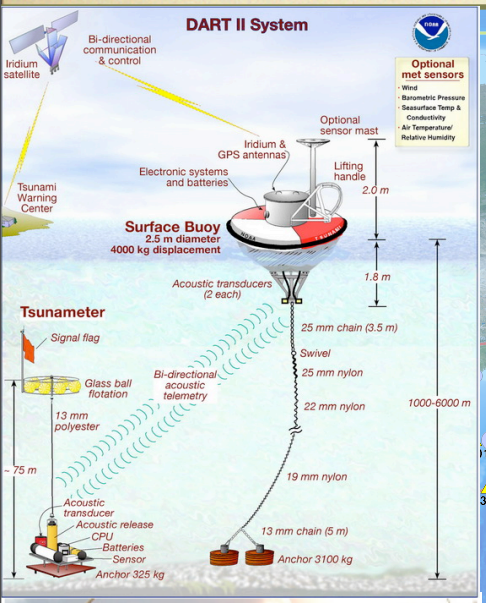

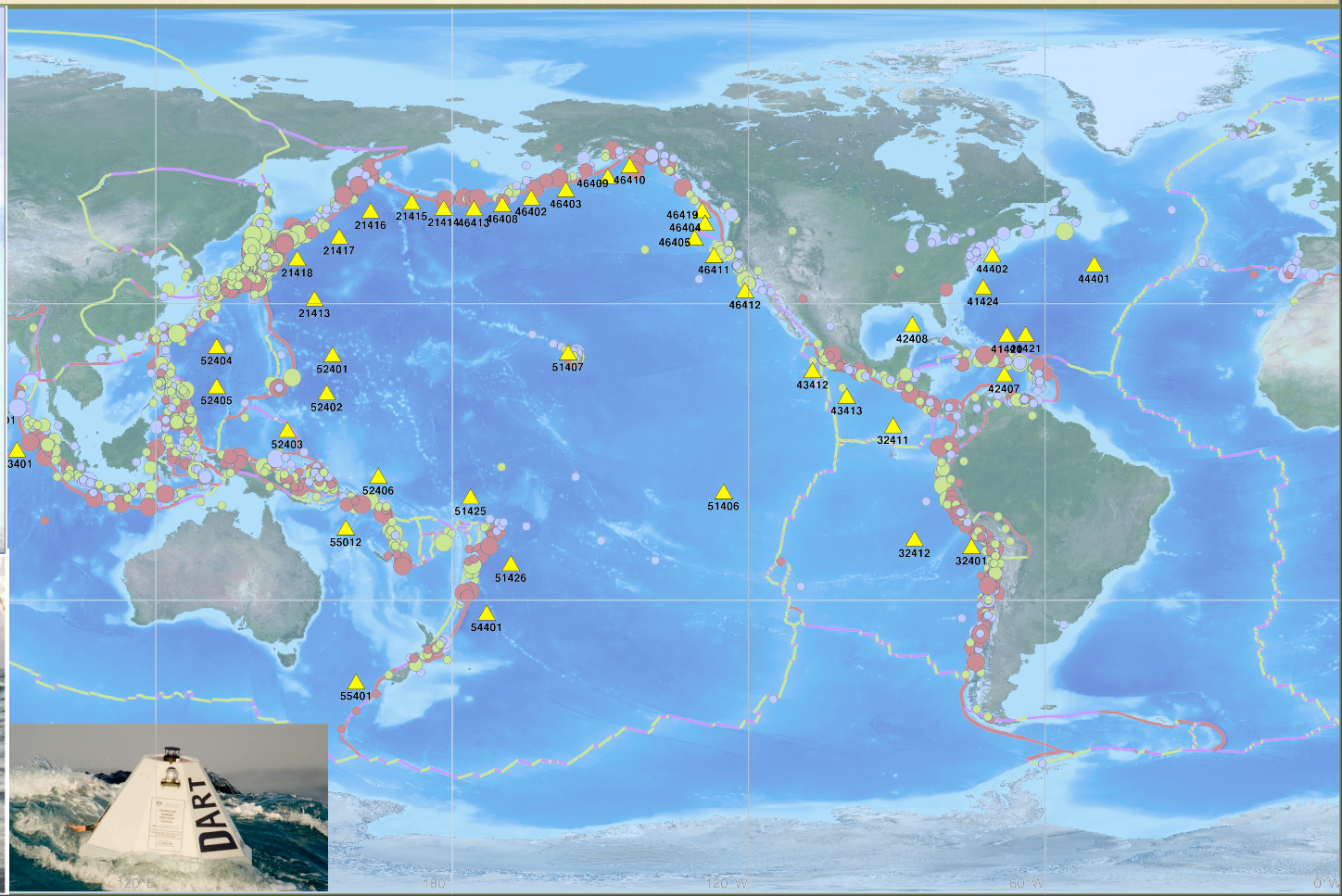

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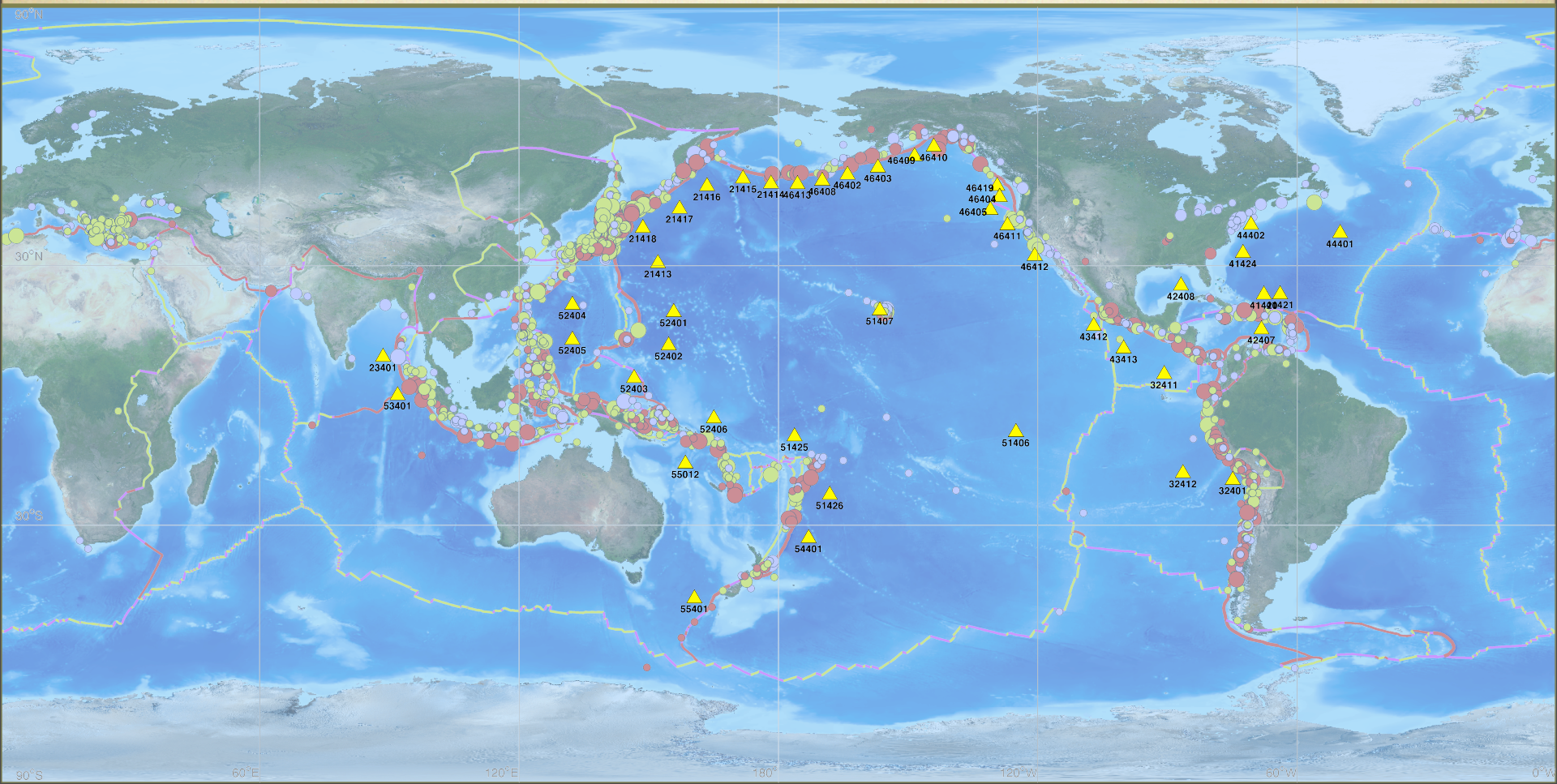

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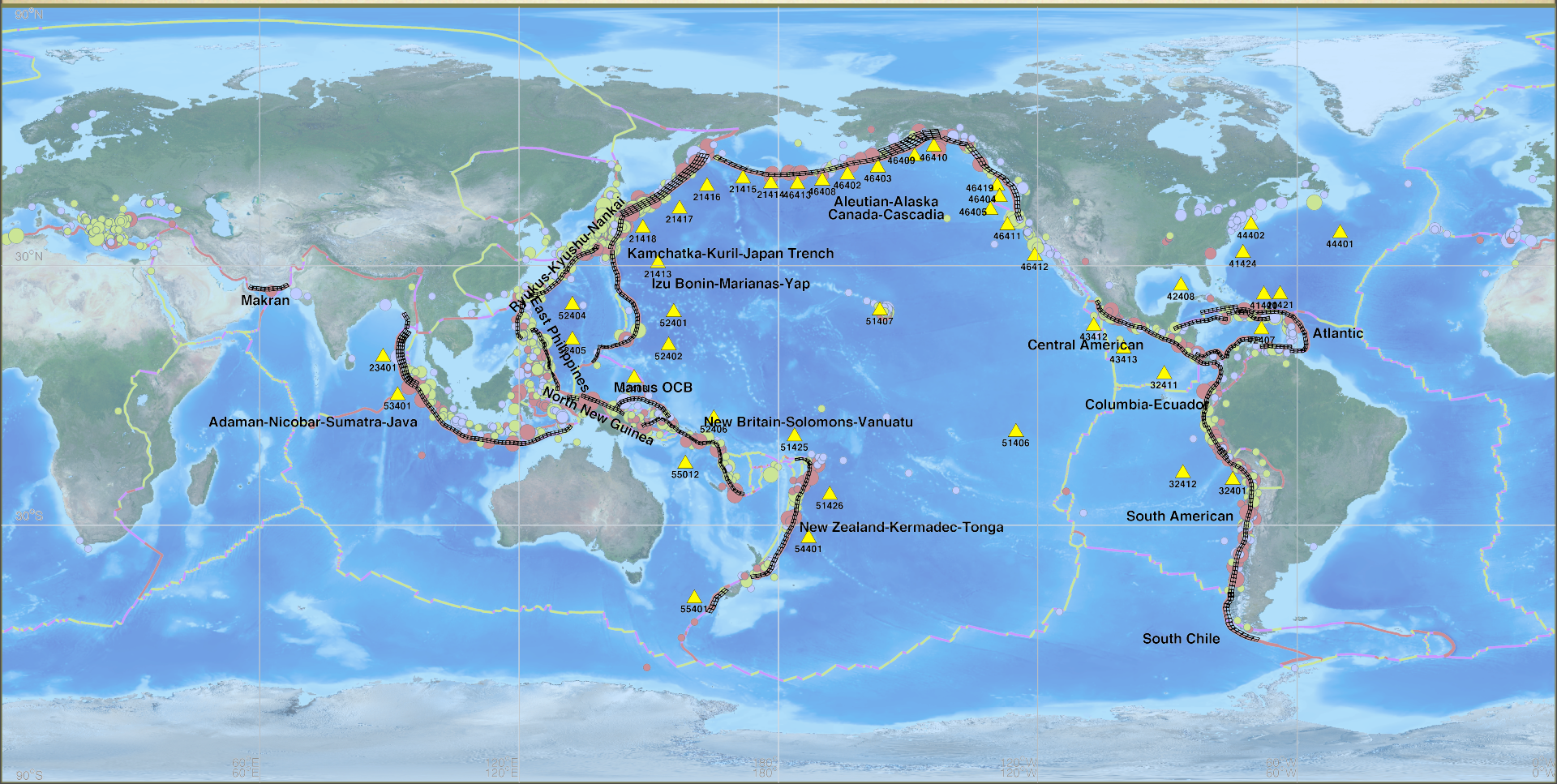

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Coastal forecast

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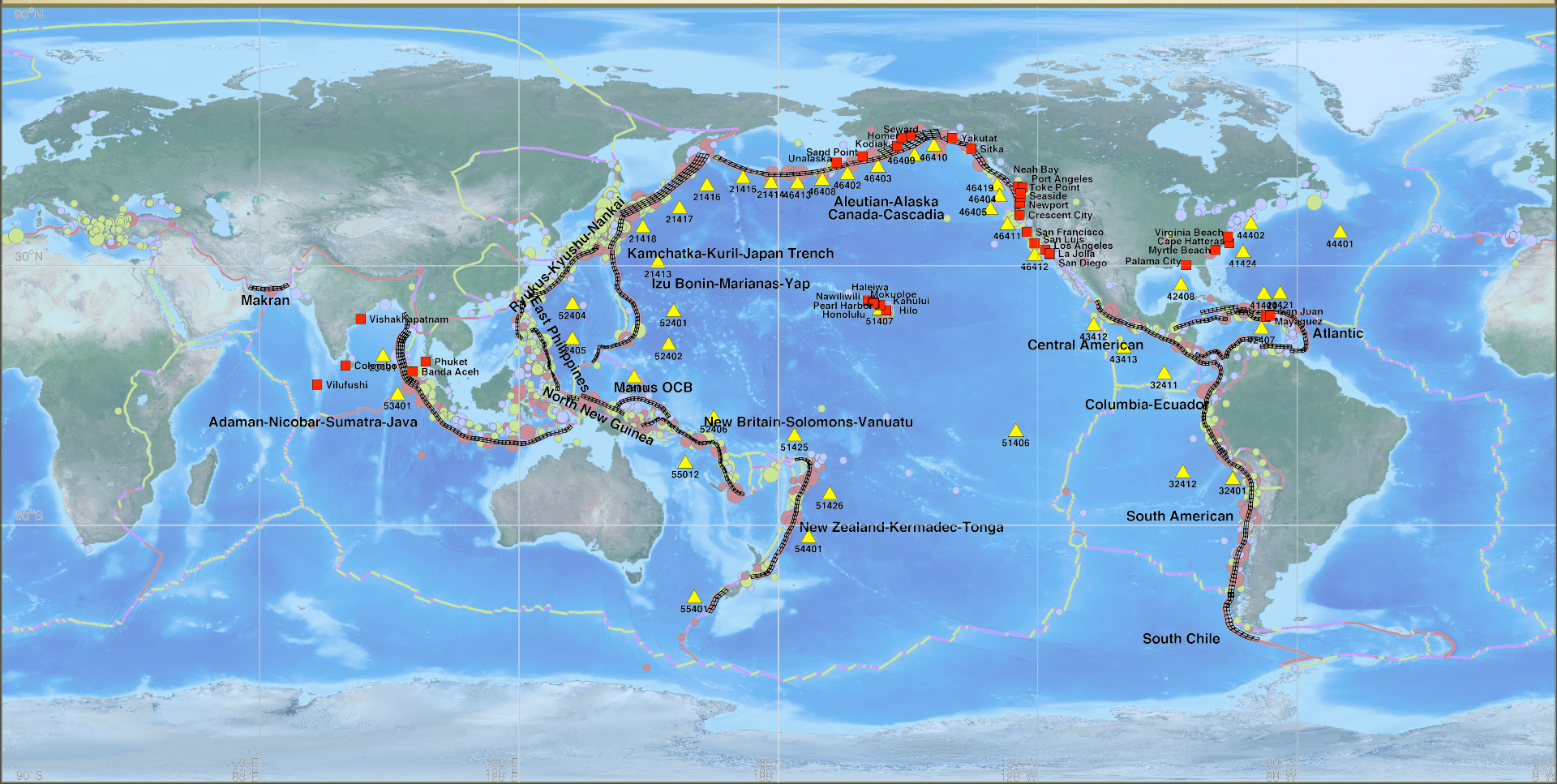

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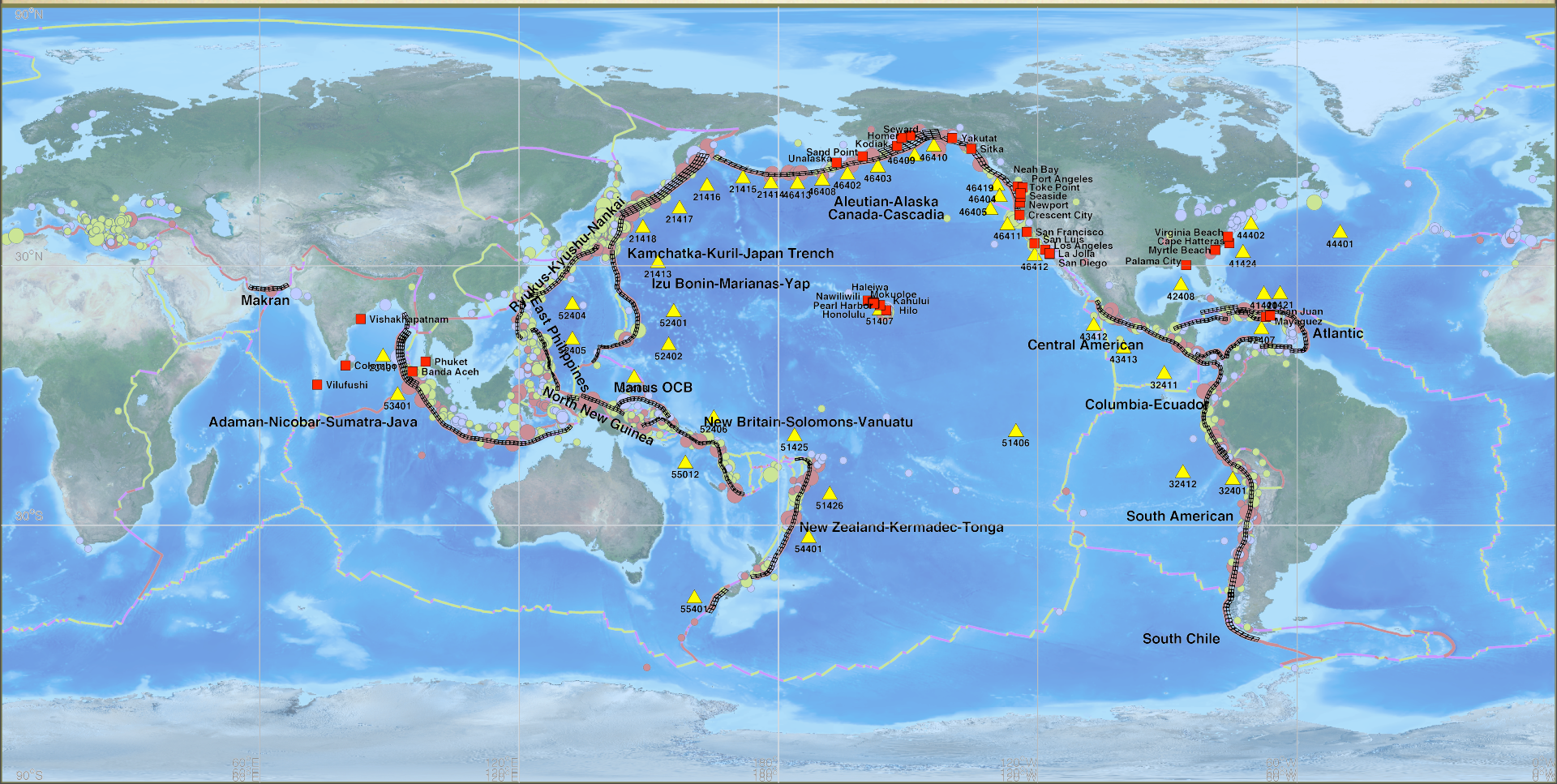

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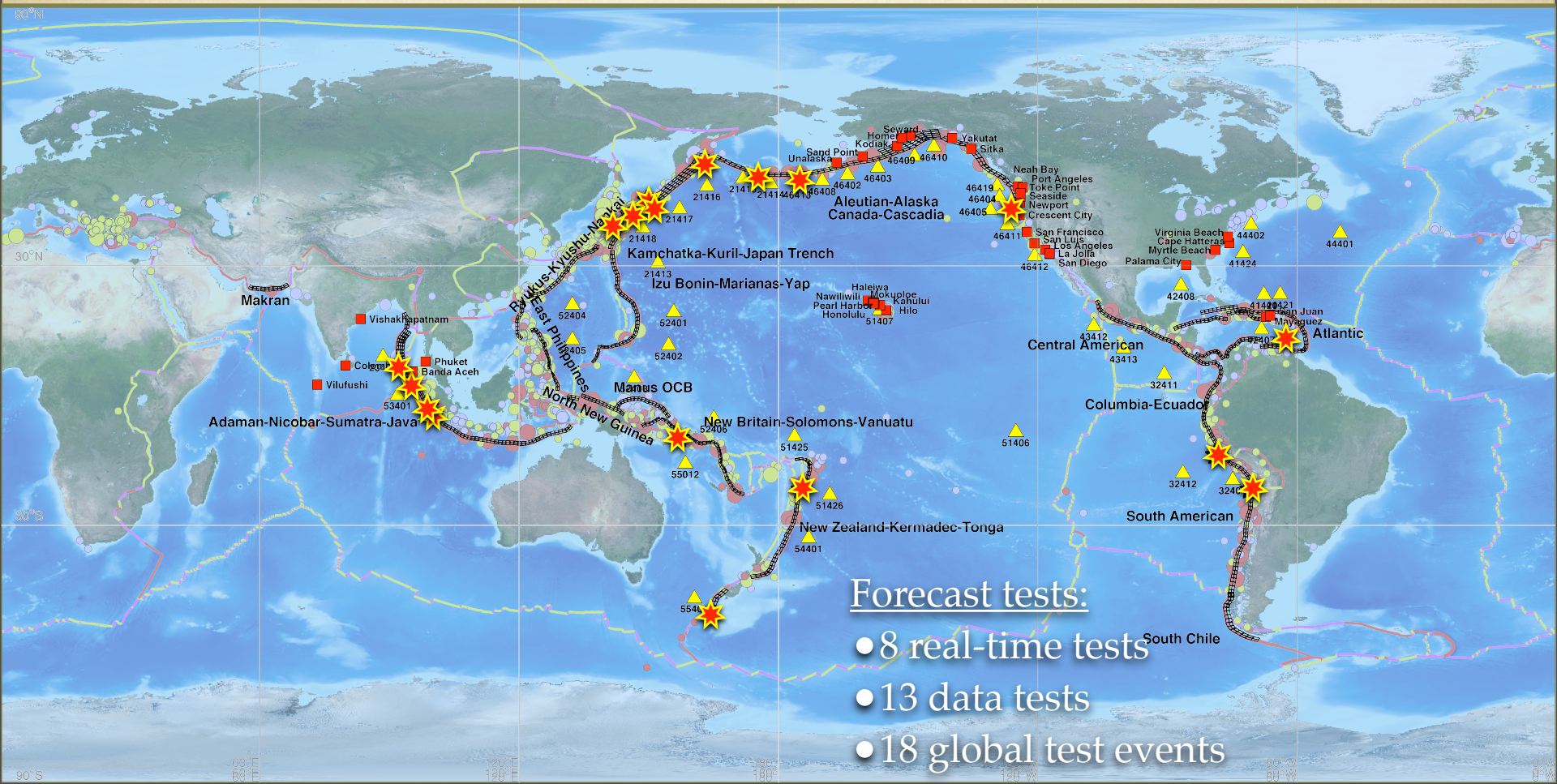

May 3, 2006 Tonga tsunami

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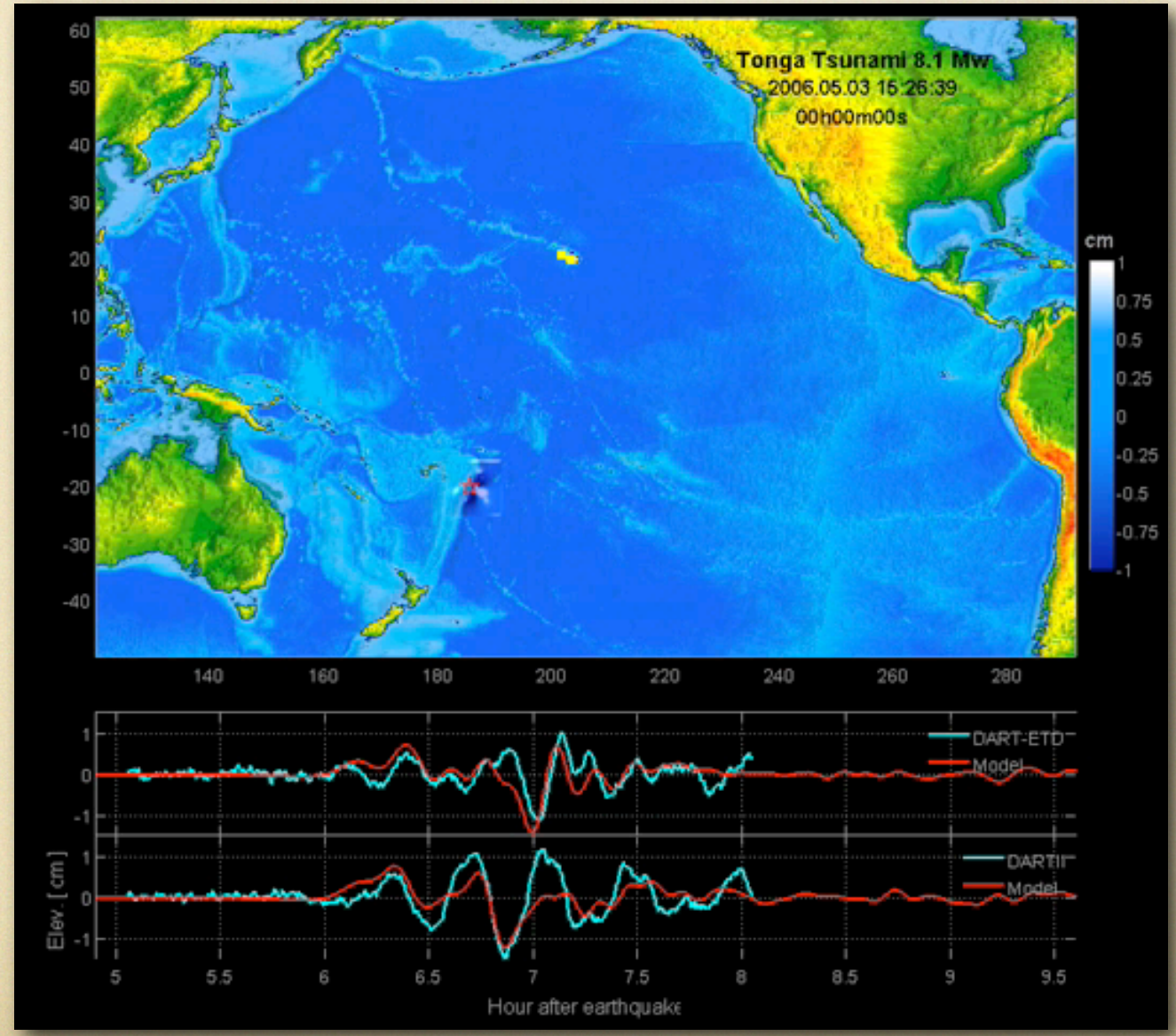

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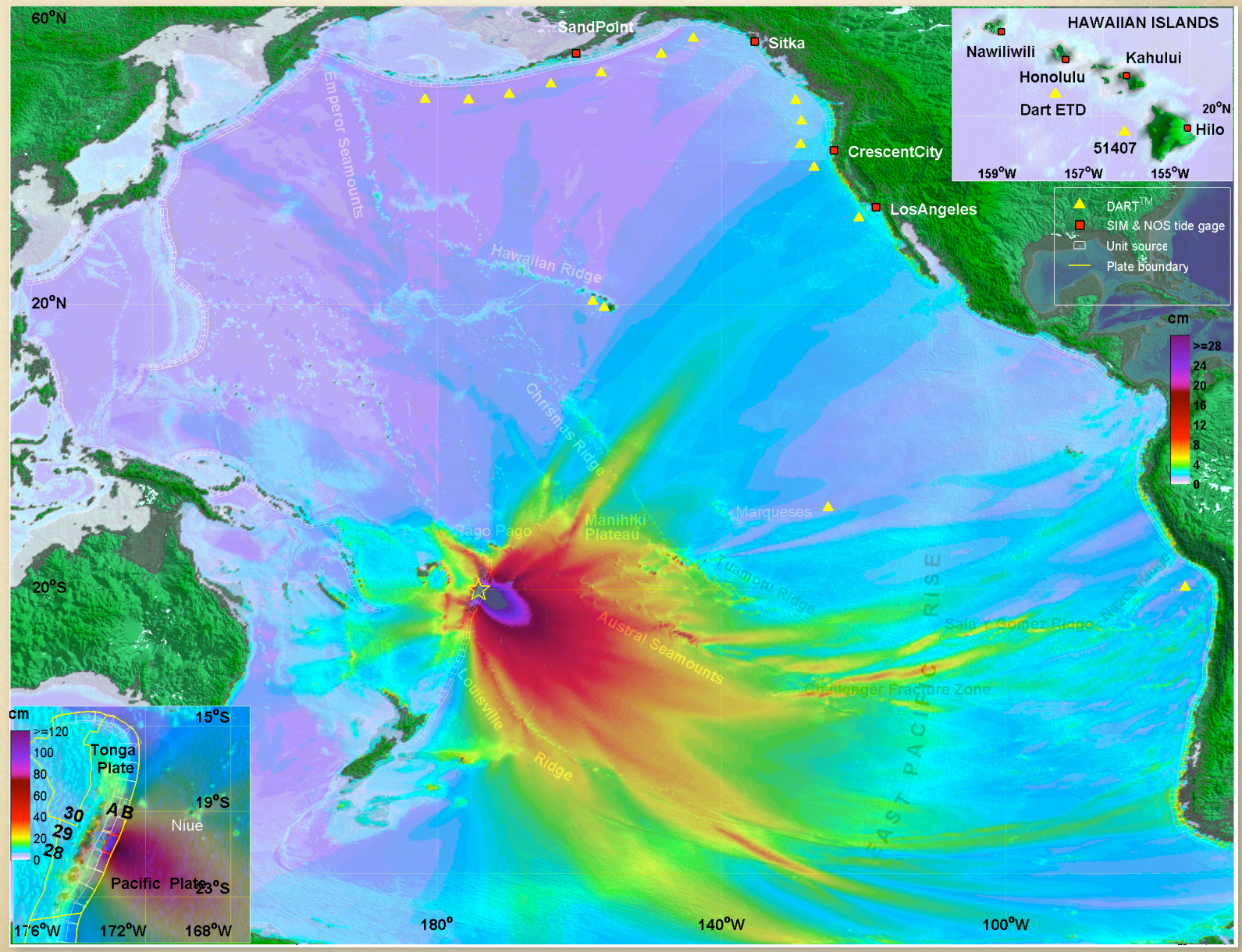
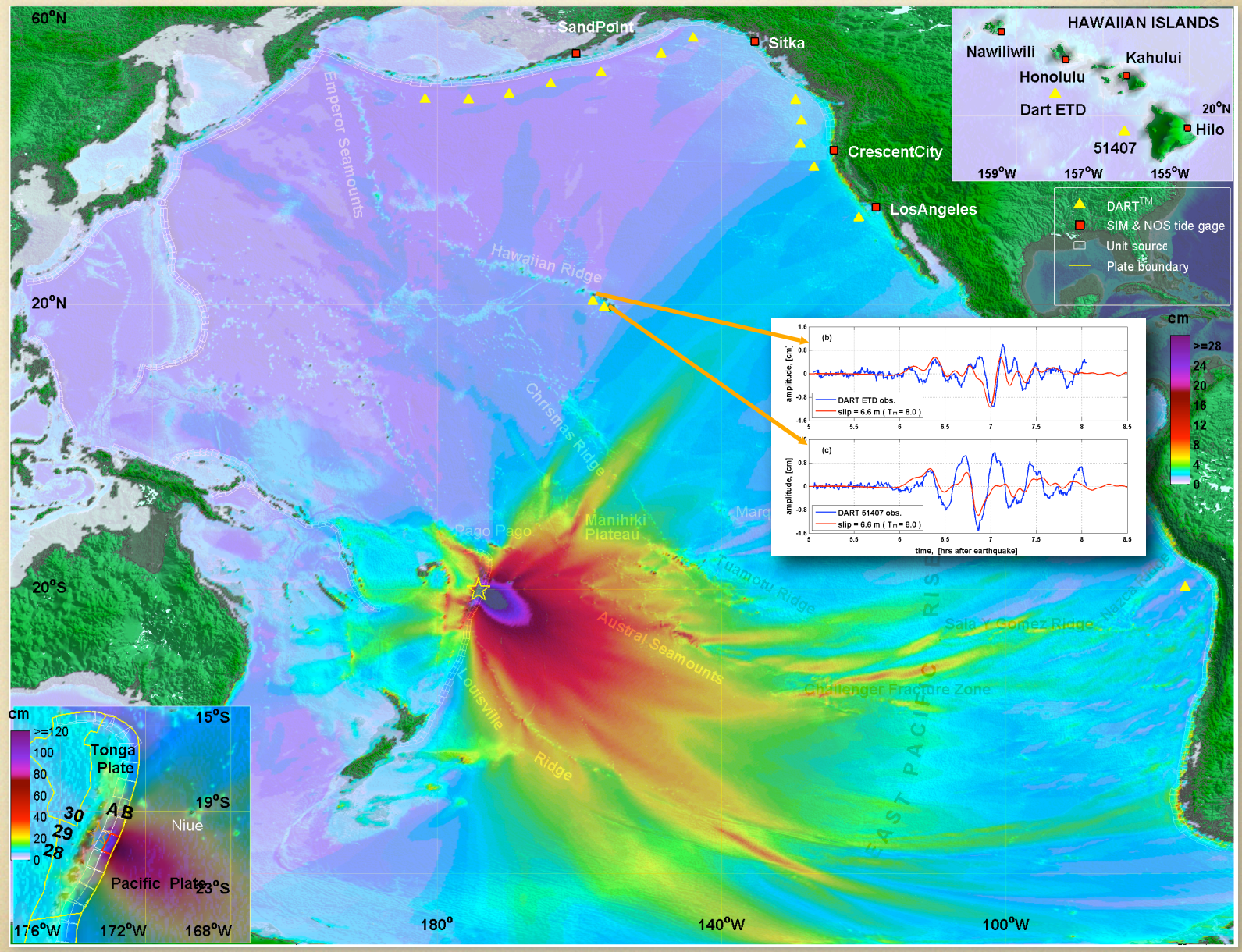


May 3, 2006 Tonga tsunami



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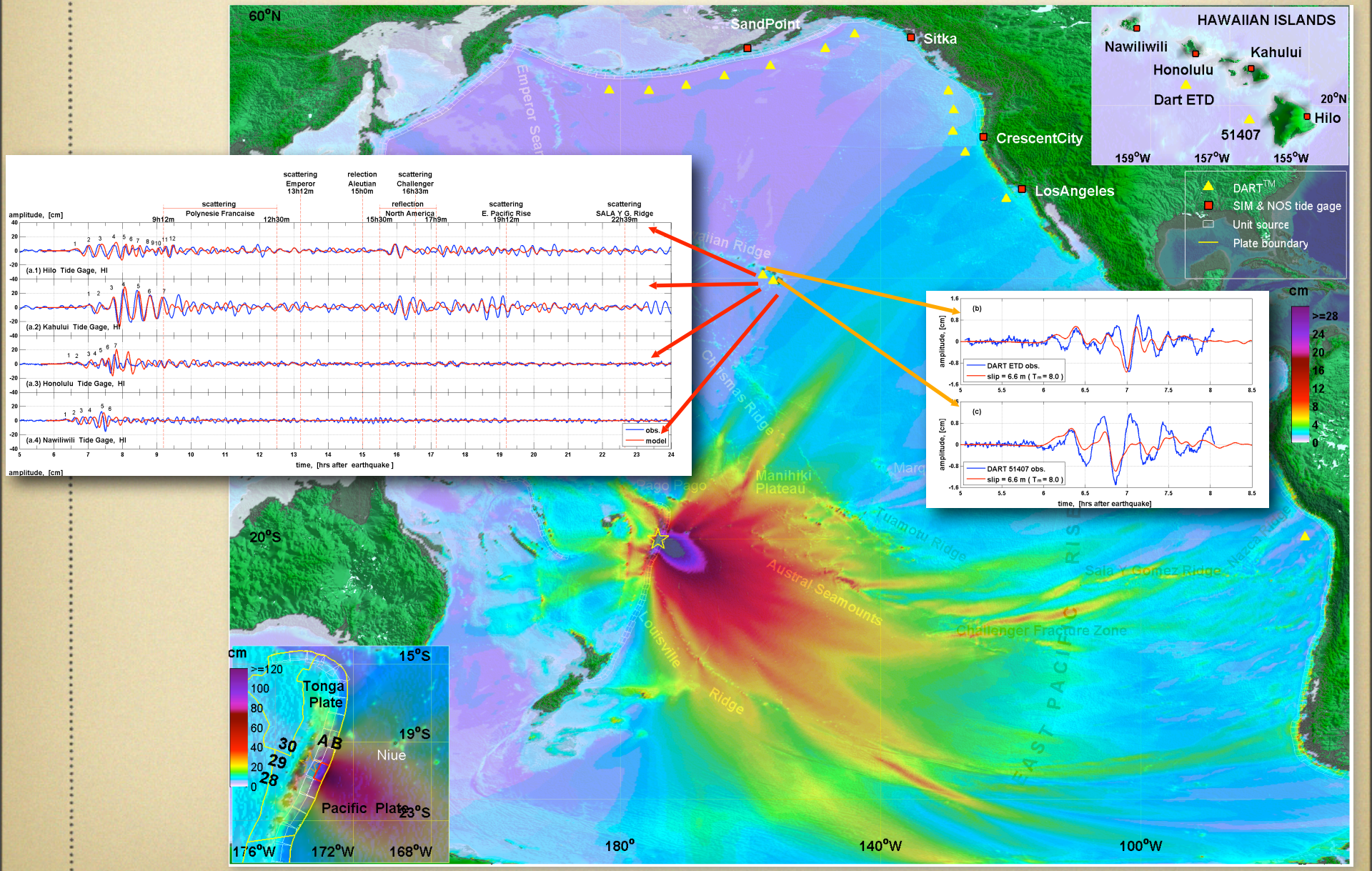
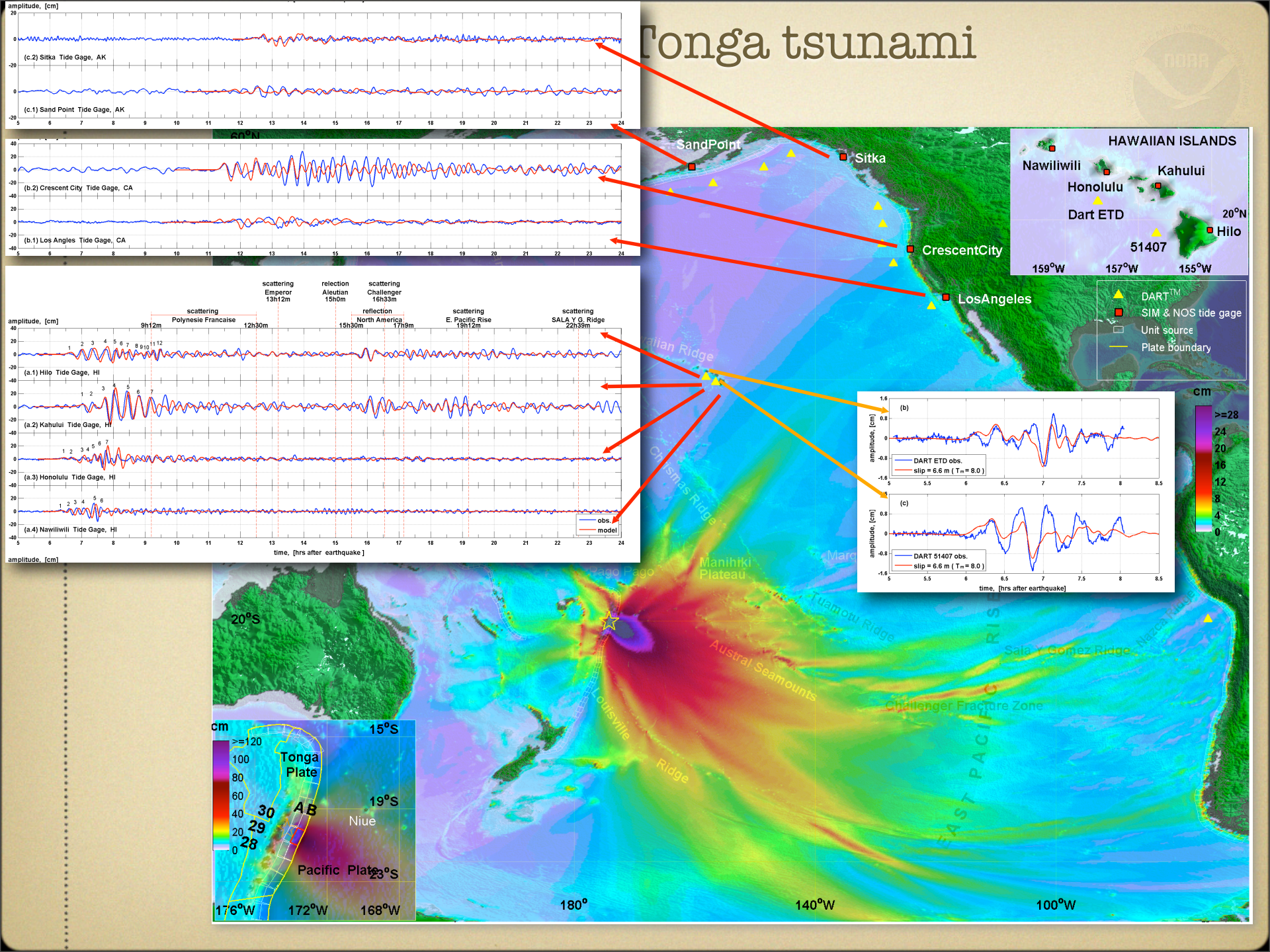
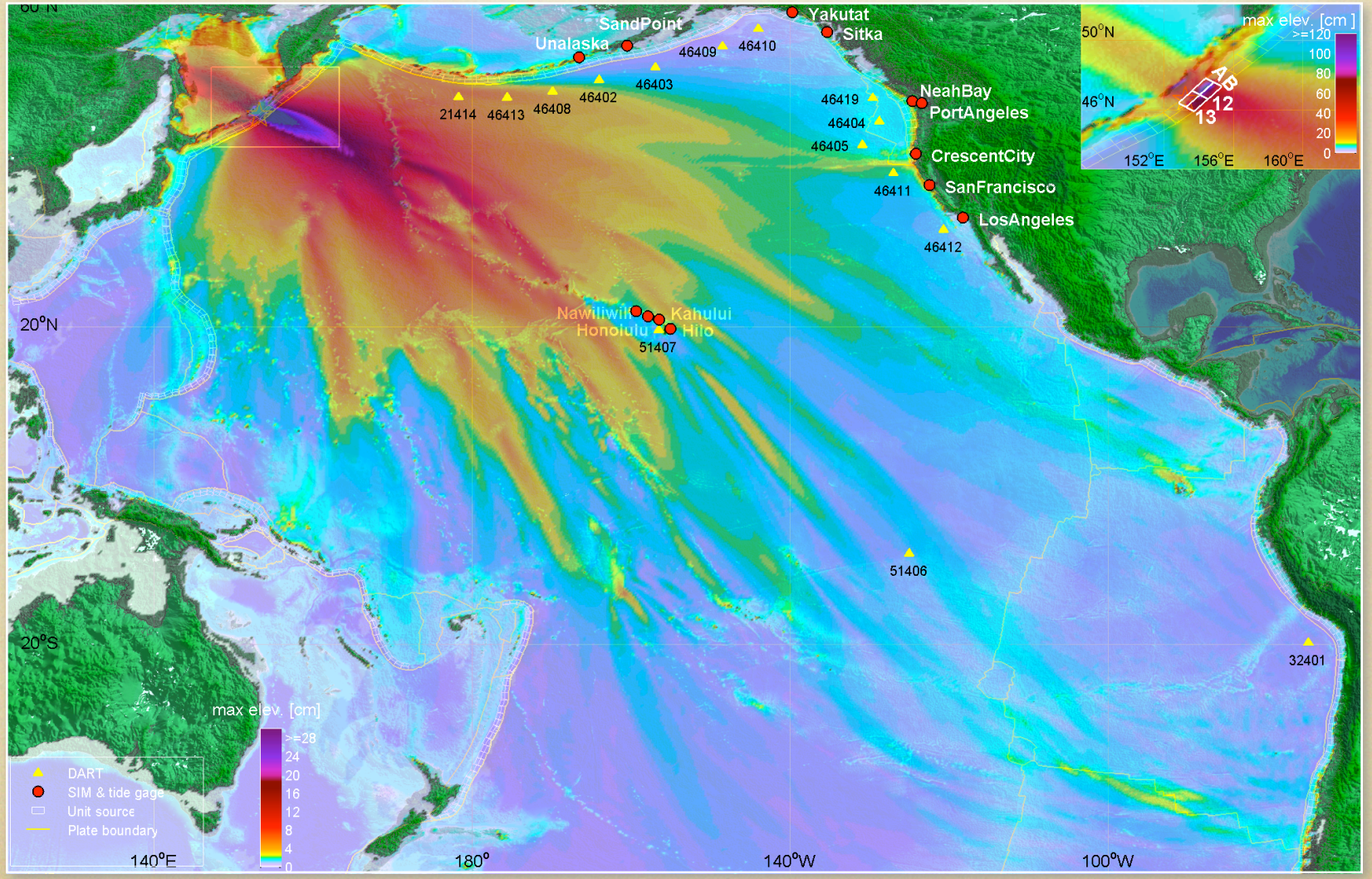


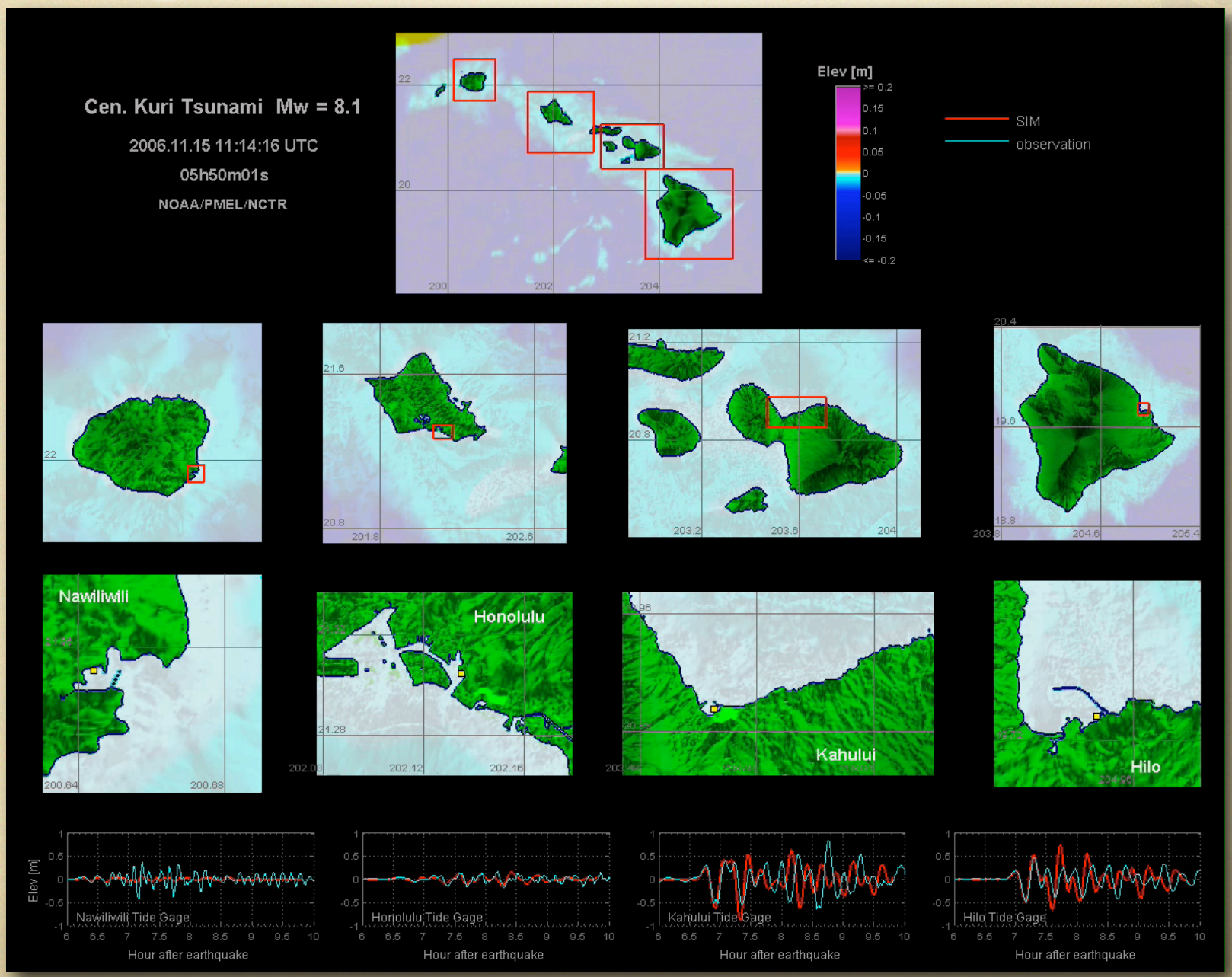
Tonga tsunami



The November 15, 2006 Central Kuril Tsunami



High-resolution forecast models



Impact of 8 Experimental Forecasts since November 2003

- 0 False Alarms
- 3 evacuations of Hawaii avoided saving approximately $210M in lost productivity
- 5 early cancellations of warnings reducing time of disruption

Brief history of tsunami science and warning

- 1933 Sanriku tsunami
  - beginning of Japan tsunami warning
- 1946 Unimak tsunami
  - US tsunami warning center in Hawaii established
- 1960 Chilean tsunami
  - IOC ITSU and IUGG Tsunami Commission formed
- 1964 Alaska tsunami
  - ATWC established
- 2004 Indonesian Tsunami
  - IO TWS formed, Several TWCs are being established, all national TWSs reforming, building forecast capabilities

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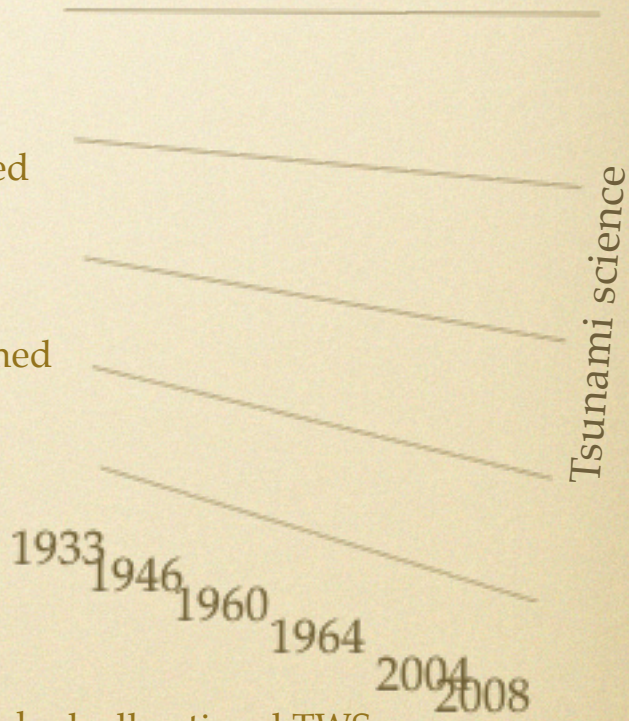

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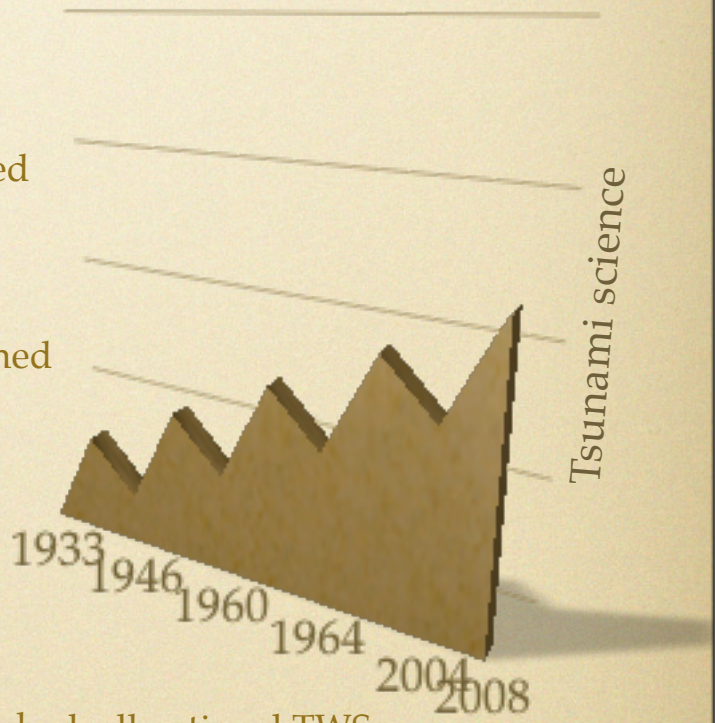

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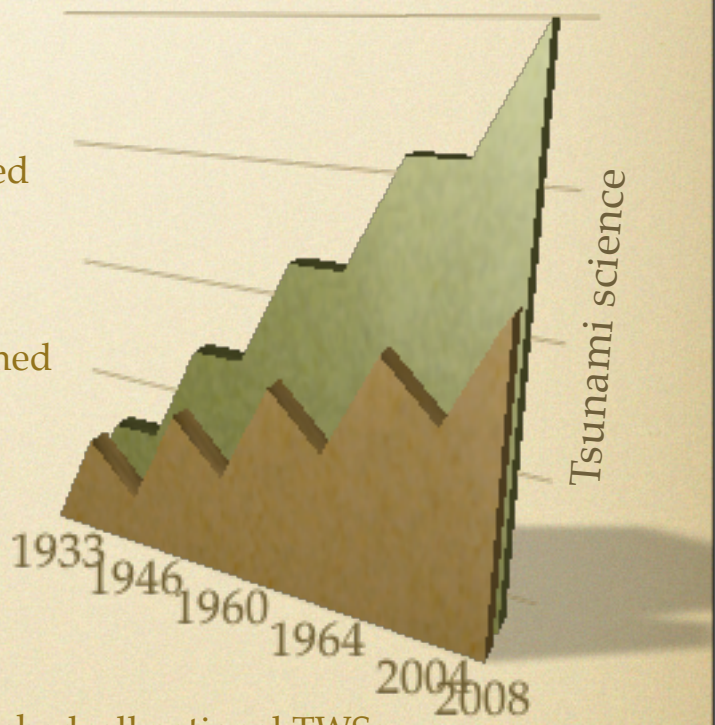
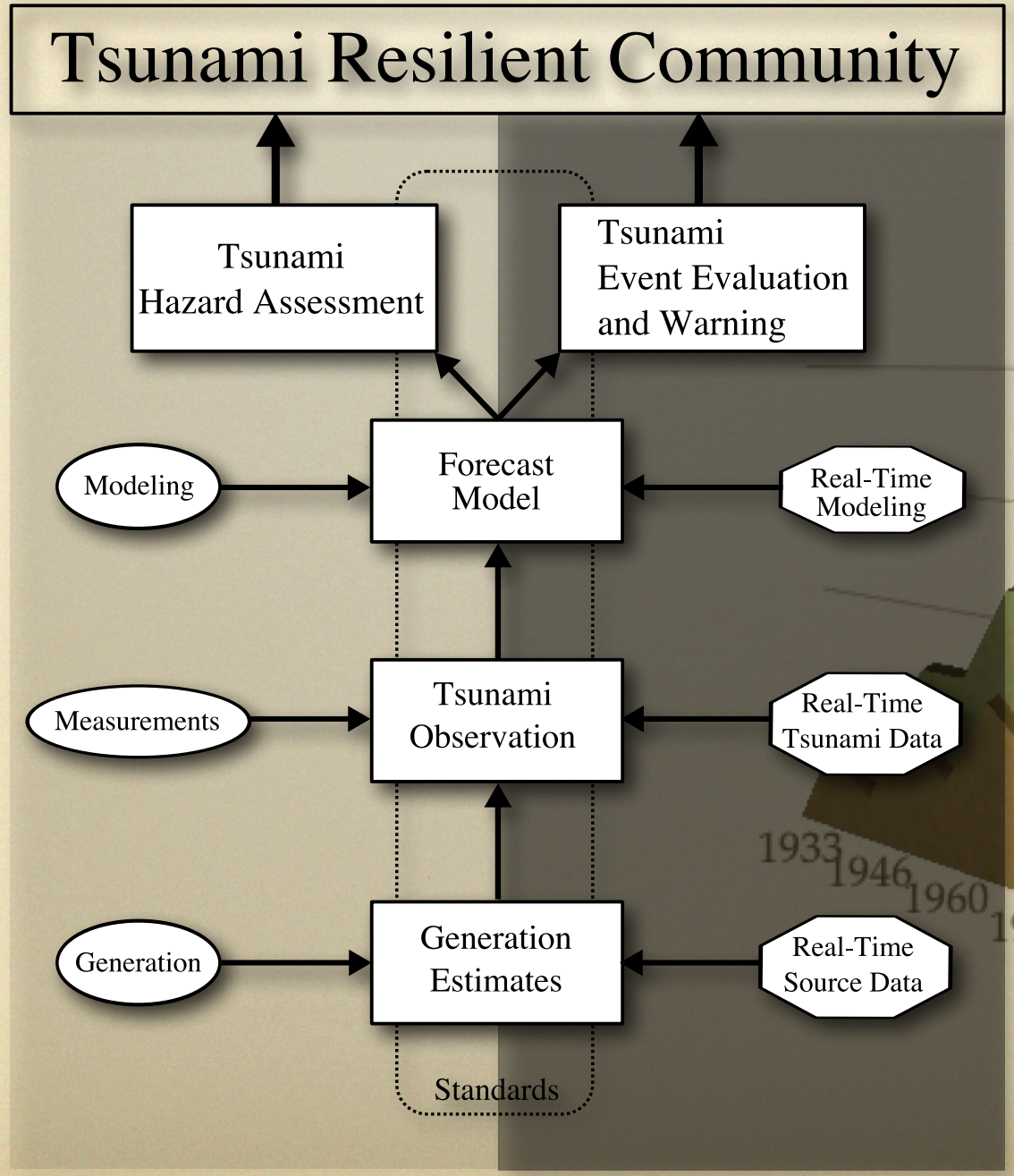


Tsunami Resilient Community



Summary

- Real-time tsunami forecast method has been developed that combines tsunami measurement and modeling into real-time capability to forecast tsunami dynamics at specific coastal locations
- Real-time experimental forecasts show up to 90% amplitude accuracy and high efficiency of the method
- Tsunami Forecast System is being transfered into operations of the U.S. Tsunami Warning System
- International Tsunami Forecast Framework may preserve tsunami science development between tsunami events